Analysis of Interactive Application in Forest Management Visualization

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Analysis of Multimodal Interaction for Forest Management Visual Simulation

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***Abstract*—In view of the complexity and diversity of forest management operation types, and the poor interaction and lack of natural and realistic interaction experience, three kinds of interaction methods for forestry practitioners were developed. [Method] through the network questionnaire survey, the content of forest management visualization method concerned by forestry related workers was obtained, and the interaction mode that forestry practitioners are interested in was selected. Based on the appropriate platform, the forest management operation interaction method was developed to visually simulate the operation process of replanting, pruning and logging. The results of the questionnaire survey showed that the three most interesting interaction modes of forestry practitioners were voice interaction (71.67%), mouse and keyboard interaction (66.67%) and body action interaction (53.89%); the interaction accuracy of voice based forest management operation interaction method was low, and the average number of operations needed to complete cutting, pruning and replanting operations was more than 3 times, which was very important in forestry The recognition accuracy of professional terms is low (86%), but the interactive experience is natural and realistic; the success rate of UI based forest management interaction method is 96%, but it needs to use the mouse to click the forest model in the virtual scene for many times, so the interaction is not natural and realistic; the success rate of body action based forest management interaction method is 90%, and each body action is not natural All of them can be correctly mapped to the forest management operation method, and the interaction is more natural and realistic.**

Keywords—forest management operation simulation, UI interaction, voice interaction, body action interaction, CAVE2

I. INTRODUCTION

The application of computer technology to forest management research and decision-making plays more and more important role in modern foresty [1-3]. At present, many researches have used computer to simulate forest management [4-7]. These studies have studied forest management theories and methods from different angles and levels, including two-dimensional chart comparison of forest state before and after management, and three-dimensional scene comparison of forest state before and after management, which can express the effect of forest management in different degrees. These studies mainly use the computer computing power and visual display effect, less consider the simulation and interaction of frequent operations in forest management. Different forest management objectives and forest status will adopt different operation methods. However, there are some hidden dangers in the field training of forest management operation, such as high cost, long cycle and great impact on the environment. The application of computer simulation of forest management operation can make up for these shortcomings to a certain extent.

At present, the common forest management simulation system provides users with a simple way of interaction, mostly through the keyboard, mouse or handle roaming interaction, which is difficult to meet the needs of forest management simulation. The virtual reality technology based on human-computer interaction provides a new idea for the simulation of forest management operation [8-11]. In the simulation of forest management operation, it can not only provide realistic forest environment, but also make the interactive mode vivid and intuitive, so that users can be on the scene. Among them, the immersive virtual reality system has the characteristics of strong sense of immersion, free interaction, wide range of virtual simulation, and multiple people can observe the virtual scene at the same time. It has great advantages in the simulation of forest management operation [12-18].

In this study, through the network questionnaire survey, the relevant contents of Forest Management Visualization concerned by forestry related workers were obtained. Based on the results of the questionnaire, this paper selects the human-computer interaction mode that forestry practitioners are interested in, and develops the forest management operation simulation interaction method based on the appropriate platform to visually simulate the operation process of replanting, pruning and logging.

II. MATERIALS AND METHODS

A. Questionnaire investigation

In order to understand the forestry related practitioners' understanding of forest management visualization simulation, this study obtained the relevant content by issuing the network questionnaire. There are four main parts in the questionnaire: basic information of filling personnel, interactive methods of forest management, forest management measures and visualization of forest information. The specific content of the questionnaire is shown in Table 1.

Through the three parts of the questionnaire, we can get the cognition of forestry workers about the visual simulation of forest management, and on this basis, we can choose the content they are interested in to realize the interactive visual simulation of forest management.

According to the results of the forest management visualization simulation questionnaire. The first three interaction modes that users are most interested in are selected: voice interaction, UI interaction and body action interaction. According to the national standards of the People's Republic of China, the types of cutting, replanting and pruning operations are selected.

TABLE I. FOREST VISUALIZATION QUESTIONNAIRE

Part	Content
Basic information of filling personnel	Gender, age, work unit, work direction, working hours, education background
Interactive methods of forest management	Human computer interaction mode, human-computer interaction equipment, interested interactive mode, reasons for liking
Forest management measures	Methods of replanting, pruning and cutting

B. UI Interaction

UI (user interface) based interaction is a classic paradigm of human-computer interaction. It realizes the interaction between human and 3D virtual scene in 2D screen by metaphor. Windows, icon and menu graphics are widely used in UI interaction to represent the functions and operations of calculation, and pointer is used to operate these graphics to realize calculation. This study adopts the following principles to design forest management operation interaction method.

(1) Metaphor principle: through the UI graphic metaphor operation simulation method, to achieve the effect of what you see is what you get. In the logging operation, buttons or pictures with logging marks (such as axes) were used; planting or filling operations were carried out with buttons or pictures with planting marks (such as shovel); pruning operations were highlighted by the pruned objects and buttons were confirmed.

(2) Hierarchy principle: the UI level is no more than 3 levels; the functions represented by UI graphics of the same level are parallel, without the relationship between included and included; the UI graphics of different levels represent the relationship between included and included functions.

The interaction method is as follows.

(1) Logging operation simulation. Click the tree and wait until the tree is highlighted; click the logging button to realize the logging.

(2) Simulation of replanting operation. Select the replanting site, and click the replanting button after the planting mark point appears to realize the replanting operation.

(3) Pruning operation simulation. Click the branch, after the branch is highlighted, click the pruning button to realize the pruning operation.

C. Voice interaction

Voice interaction is a new generation of interaction mode based on voice input. It controls the execution function of the machine through natural language, which is in line with human interaction habits. Speech interaction can be divided into speech recognition, speech synthesis and intelligent speech dialogue. The key steps are as follows:

(1) The voice transmitted by users in real time is converted into text.

(2) Customize unit interactive skills for forest management simulation.

(3) Based on the results of unit, speech synthesis and forest operation simulation are carried out to realize two-way interaction with users.

This research uses the speech recognition interface based on Baidu AI development platform to realize the function of voice to text. Forest management simulation involves a large number of professional vocabulary, which is difficult to identify accurately. When Mandarin is not standard, the accuracy of speech recognition will be significantly reduced.

Based on the EasyDL voice self-training platform provided by Baidu, the paper uploads professional vocabulary audio and annotation text in the field of forest management for model evaluation, and selects the best basic model. Taking the forest cutting operation rules as an example, some professional vocabulary audio and annotation texts uploaded are shown in Table 3. The evaluation results are shown in Table 2. It can be seen from table 2 that the recognition accuracy of Chinese Mandarin model extreme speed (API mode) is higher than the other two methods on the whole, so it is selected as the speech recognition model used in this study.

After the training of easydl platform provided by Baidu AI open platform, the accuracy of the self defined speech recognition model in identifying the names of forest management related majors is greatly improved, with an accuracy of 86%. The detailed training information is shown in table 3. It can be seen from table 3 that after training, the field accuracy rate of speech recognition model has increased from 56.9% to 86.15%, the sentence segment accuracy rate has increased from 35% to 80%, and the replacement error rate has decreased from 40% to 10.77%. Generally speaking, after training, the accuracy of the model has reached the basic requirements of application.

When the speech recognition module recognizes the user's input speech as text, it needs to take the text as the correct response, so as to achieve the two-way interaction between human and computer, and improve the natural and immersion sense of interaction. Based on Baidu's unit, we can develop an efficient and low-cost intelligent voice dialogue system. Unit function is divided into: robot, skill, dialogue management and dialogue deployment. According to the characteristics of skills, this study uses dialogue skills to construct the interactive modules of cutting, pruning and replanting operations, and uses question answering skills to construct the interactive modules of forest information query and forest management knowledge. The following is a detailed introduction of the interactive content.

(1) Cutting operations. The main content of logging interaction is that the user initiates the logging interaction request (key words: logging, logging, logging), the intelligent interaction module responds to the request (do you want to do logging), and the user enters the key words (yes, yes, yes) to confirm the request. After several rounds of dialogue, the user's final selection result is returned to the program, and the cutting operation screen is displayed in the program to realize the voice interaction function of the cutting operation.

(2) Pruning. The main content of pruning operation is that the user initiates pruning operation request (key words: pruning operation, pruning, pruning, pruning), the intelligent interaction module responds to the request (do you want to prune), and the user inputs the key words (yes, yes, yes) to confirm the request, so as to realize the voice interaction function of pruning operation.

(3) Replanting operation. The main content of replanting interaction is that the user initiates replanting interaction request (key words: replanting, replanting, planting, planting trees), the intelligent interaction module responds to the request (do you want to replant), and the user inputs the key words (yes, yes, yes) to confirm the request, so as to realize the voice interaction function of logging operation.

TABLE II. SPEECH TRAINING TABLE

Professional vocabulary audio number	Label text content
jy_1.pcm	Forest harvesting
jy_2.pcm	Selection cutting
jy_3.pcm	Shelterwood cutting
jy_4.pcm	Quantitative

TABLE III. MODEL TRAINING RESULTS

Mandarin speech recognition model interface	Assessment results		
	Word accuracy	Sentence accuracy	error rate
Speed version (API mode)	56.9%	35%	40%
Common version (API mode)	50.7%	25%	47.7%
Common version (SDK mode)	38.5%	10%	49.2%

TABLE IV. SPEECH TRAINING TABLE

Training results	Training results before	Training results before
Word accuracy	56.9%	86.15%
Sentence accuracy	35%	80%
Replacement error	40%	10.77%
Deletion error	1.54%	1.54%

D. Body movement interaction

Cave2, an immersive virtual reality system, has the characteristics of strong immersion, free interaction, wide range of virtual simulation, and many people can observe the virtual scene at the same time. It has great advantages in the simulation of forest management operation. The system can use the infrared tracking sensor module to obtain the spatial coordinates and direction information of the sensitive object in real time, and judge the user's interaction needs by tracking the user's body motion trajectory.

In this study, the infrared tracking module of cave2 is used to develop a limb action interaction model for forest management simulation, which can realize the process of logging, planting and pruning. When the hand-held photosensitive object moves in cave2, the spatial motion trajectory of the user's body movement can be obtained in real time (Fig. 1)

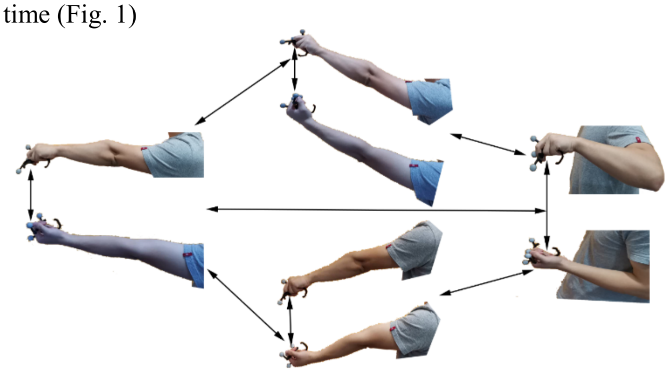


Fig.1. Body action

1. Movement model of logging operation

（1）Limb action: dis represents the distance between the limb and the coordinate origin at the current frame, predis the distance of the previous frame, log_ FarDis is away from the collection, log_ NearDis is near collection, log_

AllDis is a collection away from and near, and dir is the direction of limb movement in the current frame, log_ Dir is a collection of limb movement directions

$$Log\_FarDis+=[Dis>preDis] \quad (1)$$

$$Log\_NearDis +=[Dis<preDis] \quad (2)$$

$$Log\_AllDis+=[Log\_FarDis,Log\_NearDis] \quad (3)$$

$$Log\_Dir +=[Dir] \quad (4)$$

（2）Constraint condition: diff (log)_ FarDis,Log_ Neardis represents the difference between the amount of data far away from the set and the amount of data close to the set, maxdiff is the maximum difference of the amount of data allowed; num (log)_ Alldis) is the number of body movements repeated, and minnum is the minimum number of body movements to be repeated_ DIR) represents the angle change between the body action and the user, and maxangle represents the maximum angle that the body action is allowed to deviate from.

$$Diff(Log\_FarDis,Log\_NearDis)<maxDif \quad (5)$$

$$Num(LogAllDis)>minNum \quad (6)$$

$$Angle(Log\_Dir)<maxAngle \quad (7)$$

2. Limb movement model of pruning operation

（1） Limb action: dis represents the distance of the limb movement at the current frame, predis the distance of the previous frame, prune_ Fardis is away from the collection, prune_ Neardis is near the collection, dir is the direction of limb movement in the current frame, prune_ Dir is a collection of limb motion directions.

$$Prune\_FarDis += [Dis > preDis] \quad (8)$$

$$Prune\_NearDis += [Dis < preDis] \quad (9)$$

$$Prune\_Dir += [Dir] \quad (10)$$

（2）Constraints: diff (prune_FarDis,Prune_Neardis) indicates the difference between the data far away from the collection and the amount near the set, maxdiff is the maximum allowed data amount difference; angle (prune_DIR) indicates the relative angle change of limb action and user, maxangle represents the maximum angle allowed to deviate from limb action; branch_ Size represents the branch diameter; minsize is the minimum branch diameter required for pruning.

$$Diff(Prune\_FarDis,Prune\_NearDis) < maxDiff \quad (11)$$

$$Angle(Prune\_Dir) < maxAngle \quad (12)$$

$$Branch\_Size > minSize \quad (13)$$

3. Limb movement model of planting operation

（1）Limb action: dis represents the movement distance of the limb in the current frame, and represents_ DIS is the set of motion distances of limbs; dir is the motion direction of limbs in the current frame, and represent_ Dir represents the set of motion directions of the limbs.

$$Replant\_Dis += [Dis] \quad (14)$$

$$Replant\_Dir += [Dir] \quad (15)$$

（2）Constraints: far2near (replant_ DIS) to determine whether the limb movement is far first and then near_ Dis(Replant_ DIS) to determine whether the distance between the limb and the ground is continuously reduced; pos2neg (land)_ DIR) to determine whether the angle between the limb and the horizontal plane changes from positive to negative_ Angle(Replant_ DIR) represents the maximum change in the horizontal angle of the limb, maxangle is the angle of deviation allowed in the horizontal direction of the limb; replant_ Time is the length of contact between the planting tool and the ground, and mintime is the minimum time to contact; replant_ Point represents the distance between the track of movement and the surrounding trees, and mindis is the minimum spacing for planting.

$$Far2Near(Replant\_Dis) \quad (16)$$

$$Vertical\_Dis(Replant\_Dis) \quad (17)$$

$$Pos2Neg(Replant\_Dir) \quad (18)$$

$$Horizontal\_Angle(Replant\_Dir) < maxAngle \quad (19)$$

$$Replant\_Time > minTime \quad (20)$$

$$Replant\_Point(Replant\_Dis) > minDis \quad (21)$$

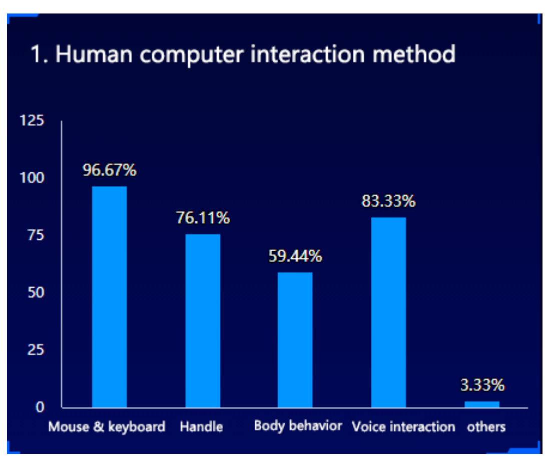
III. Process and Results

A. *Forest management Interactive survey results*

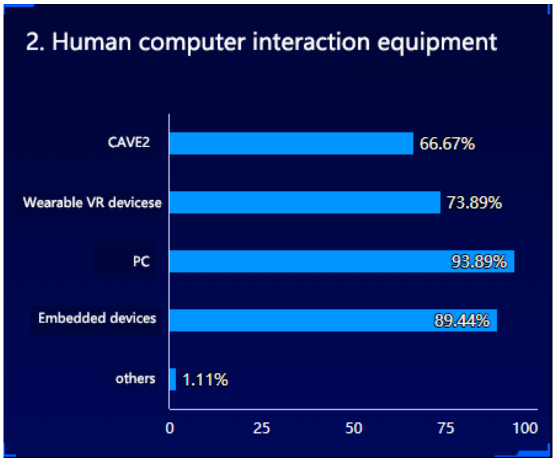
The understanding of human-computer interaction includes: human-computer interaction mode, human-computer interaction equipment, preferred forest management interaction mode, and reasons for liking this interaction mode. Some statistical results are shown in Fig 2.

It can be seen from figure 2a and figure 2b that most people understand most of the modern human-computer interaction modes and interactive devices. Basically, all people (96.6%) are familiar with the mouse and keyboard based interaction (UI interaction). Secondly, 83.7% of people understand voice interaction. On the one hand, it may be because the related concepts of voice interaction are widely publicized in the society; on the other hand, it may be because of the lack of knowledge The participants have experienced voice interaction with smart devices such as mobile phones and tablets. Human computer interaction mode and human-computer interaction equipment are closely linked. Different interaction modes have their own adaptive interaction equipment, such as mouse and keyboard interaction for desktop PC, body behavior interaction for virtual simulation platform cave2, etc.

From figure 2c and figure 2d, it can be seen that most people like voice interaction. The main reason may be that voice interaction is similar to the way of communication between people, so the interaction is natural and the experience is good. Secondly, the mouse and keyboard interaction is widely accepted because of its simple operation and easy to understand. At present, the development of body behavior interaction is relatively slow, and the experience is poor, so part of it is difficult to understand People don't know much about it, but they are more interested in it.



a



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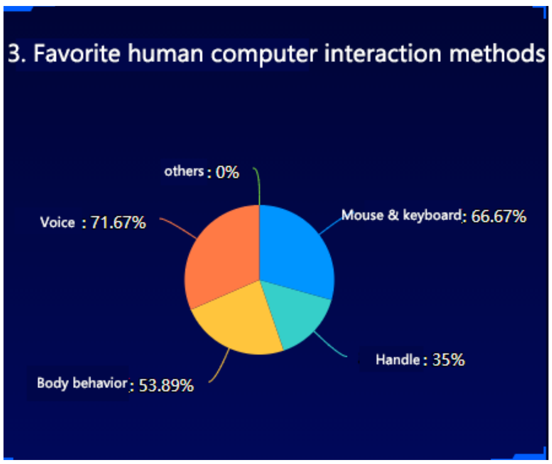

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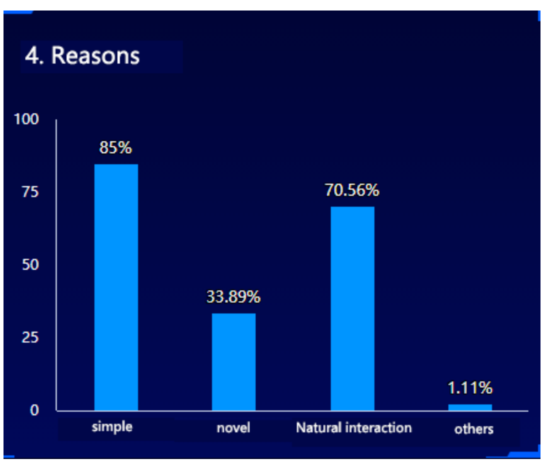

d

Fig.2. Statistical results of interactive questionnaire

B. UI Interaction

a

b

c

d

Fig.3. UI interface.

C. *Voice interaction*

In this study, we conducted 10 successful interaction experiments on each function in the simulation scenario, and counted the average number of successful interactions. The results are shown in table 5.

TABLE V. SPEECH TRAINING TABLE

times to complete the operation	Cutting	Pruning	Replanting	Search	FAQ
Less than 3	3	2	3	7	7
More than 3 Less than 5	5	4	5	3	3
More than 5	2	4	2	0	0

D. *Body action interaction*

In order to verify whether the limb actions constructed in this study can be accurately mapped to forest management measures and meet the requirements of forest management, 15 graduate students (10 with forest background) and 3 researchers involved in forest management were invited to make corresponding limb actions according to the management measures in the simulated scenario by using virtual management tools until the operation is successful. The statistical results are as follows As shown in Table 6.

According to table 6, most users can successfully complete forest operation only once, with a success rate of 86%, and all limb actions can be correctly mapped to forest management measures. The number of people who completed the operation once: UI operation (18) > planting (16) > logging (15) > pruning (13). Among them, the minimum number of people who completed the operation at one time is pruning, with 13 people and 3 requiring more than two times. Through analysis, one is that the contact range of branches is small, which is easy to cause contact interruption; second, because the limb movement amplitude changes greatly, some motion track points will deviate, which is prone to cause coordinate and direction misjudgment, and logging operation has similar problems. Because of the time judgment involved in the replantation operation, people's different feelings about time will also lead to time misjudgment. UI operation only needs to judge the relative direction of the start and end point of the hand, without other constraints, the success rate of a single operation can reach 100%.

times to complete the operation	Log	Prun	Replant	UI
once	15	13	16	18
twice	2	2	2	0
more than twice	1	3	0	0

IV. CONCLUSION AND DISCUSSION

Based on the analysis of the questionnaire related to forest management visualization simulation, this paper aims to understand some forest management visualization related contents that are concerned and interested by forestry practitioners, and select three forest management interaction modes that users are interested in: UI interaction, voice interaction and body action interaction; select common forest management operation types: logging, replanting and pruning; select forest information visualization mode Content: forest information visualization, stand structure information visualization, stand statistics information visualization.

Among them, the interaction mode based on UI has the highest accuracy, and the visual simulation of forest management operation is well realized based on the mapping of buttons with forest management operation method and forest information visualization content, but the method expansion and reuse are complex; the interaction mode based on body action realizes the body action and forest management operation method through user-defined body action model Finally, it is a voice based interactive mode, because the author's Putonghua pronunciation is not standard and the speech recognition framework is not perfect, it can not achieve a good mapping of voice and forest management operation methods and information visualization content, But the method is easy to expand and reuse, and can be well applied to other application scenarios.

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References

[1] Poudyal B H, Maraseni T N, Cockfield G. Impacts of forest management on tree species richness and composition: Assessment of forest management regimes in Tarai landscape Nepal[J]. Applied Geography, 2019,111(4):1-11.

[2] Fahey R T, Alveshere B C, Burton J I, et al. Shifting conceptions of complexity in forest management and silviculture[J]. Forest Ecology and Management, 2018,421(9):59-71.

[3] Leidinger J, Seibold S, Weisser W, et al. Effects of forest management on herbivorous insects in temperate Europe[J]. Forest Ecology and Management, 2019,437(1):232-245.

[4] Haara A, Pykalainen J, Tolvanen A, et al. Use of interactive data visualization in multi-objective forest planning[J]. Journal of Environmental Management, 2018,210(1):71-86.

[5] Tohru N, Hidesato K, Matsumoto M. Visualization of optimized solution space using a simulation system for the development of local forest management planning[J]. Annals of Forest Research, 2016,59(1):117-128.

[6] Buckley D J, Ulbricht C, Berry J K. The Virtual Forest: Advanced 3-D Visualization Techniques for Forest Research and Management[J].

[7] Tohru N, Hidesato K, Matsumoto M. Visualization of optimized solution space using a simulation system for the development of local forest management planning[J]. Annals of Forest Research, 2016,59(1):117-128.

[8] Abe M, Yoshimura T, Koizumi S, et al. Virtual forest: design and evaluation of a walk-through system for forest education[J]. Journal of Forest Research, 2005, 10(3): 189-197.

[9] Fabrika M, Valent P, Scheer Ľ. Thinning trainer based on forest-growth model, virtual reality and computer-aided virtual environment[J]. Environmental modelling & software, 2018, 100: 11-23.

[10] Huang J, Lucash M S, Scheller R M, et al. Walking through the forests of the future: using data-driven virtual reality to visualize forests under climate change[J]. International Journal of Geographical Information Science, 2020: 1-24.

[11] Kohek Š, Strnad D, Žalik B, et al. Interactive synthesis and visualization of self-organizing trees for large-scale forest succession simulation[J]. Multimedia Systems, 2019, 25(3): 213-227.

[12] F Anastacio, P. Prusinkiewicz, M. Sousa, “Sketch-based parameterization of L-systems using illustration-inspired construction lines and depth modulation,” Computers & Graphics, vol.33, pp. 440-451, June 2009.

[13] Mattila O, Korhonen A, Pöyry E, et al. Restoration in a virtual reality forest environment[J]. Computers in Human Behavior, 2020, 107: 106295.

[14] Li Meng. Research on Immersive forest landscape display based on somatosensory interaction [J]. Beijing Forestry University, 2013: 06-24.

[15] Qin long. Interactive guide design of Forest Park Based on experience perspective [J]. Journal of South China Normal University (SOCIAL SCIENCE EDITION), 2018, 50 (4): 184-188

[16] Li Yongliang, Shen Kang, Zhang Huaiqing. Research on Application of forest virtual simulation system based on cave2 [J]. Forestry resource management, 2019, (issue 2)

[17] Fu Xiu, Xin Ying, Gu zhoupeng. Structural design of an intelligent trunk whitening device based on human-computer interaction [J]. Forest engineering, 2016, (issue 5)

[18] Haara A, Pykäläinen J, Tolvanen A, et al. Use of interactive data visualization in multi-objective forest planning[J]. Journal of environmental management, 2018, 210: 71-86.