Research on Interactive System of Science Exhibition Based on Leap Motion

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Abstract. Objective In order to explore the application of non-contact interaction in Science exhibition, an interactive system of science exhibits based on leap motion technology is proposed. Method Based on the Leap motion-based Science exhibition interactive system, the design of a “planetary story” science exhibit with interactive experience is evaluated according to three interactive experience indicators: realism level, learning pressure level and pleasure level. In this way, the feasibility of Leap motion technology in the popular science interactive system is verified. Result The use of the Leap motion gesture interaction library, combined with Unity3D development tools, to design science exhibits. Conclusion By proposing an Science exhibition interactive system based on Leap motion, it provides a design theory for the development of popular science exhibits. At the same time, the combination of Leap motion and popular science exhibits improves the user's interactive experience and meets users' interest in popular science content.

Keywords: leap motion; interactive system; user experience; popular science exhibits

1. Introduction
Science exhibition as an important means of communication for understanding scientific knowledge, its interactive experience affects people's participation in popular science activities. With the rapid development of science and technology, the interactive technology of 3D gesture recognition has come one after another. Based on this, the interaction mode of Science exhibition should be considered from the perspective of user experience, and the gesture interaction technology is applied to the popular science exhibits [1]. The current Science exhibition is mainly presented to the audience through two-dimensional and three-dimensional methods. The audience interacts through direct contact in the process of participation. This form of interaction is relatively simple, and the user is difficult to distinguish in the participation process. Therefore, this study introduces the Leap motion somatosensory device by analyzing the Science exhibition interactive system based on Leap motion, which can enrich the interactive experience of the audience and solve the problem of poor user experience.

2. Related research on Leap motion technology
Leap motion sensors detect and track hands, fingers or rods, capture their position in real time with high precision, high tracking frame rate, and identify related gestures and actions. The modules of the Leap motion sensor include two high frame rate cameras, LED lights, infrared filters and a USB 3.0...
chip. Through the tracking of the object, the instruction of the gesture to the PC is realized, and finally the interactive object is controlled, as shown in Figure 1.

![Figure 1. The Interactive demonstration of leap motion](image)

In China, Li Yinghui et al [2] proposed a three-dimensional gesture recognition method based on the somatosensory device Leap Motion, and established a one-hand and two-hand static three-dimensional gesture library. In view of the traditional sand painting demonstration process, the performer needs to carry the sand table, fine sand and projection equipment, and has high requirements on the scene light and environment. Jin Yunhuan [3] designed a virtual sand painting based on Leap motion gesture interaction. Display system. In order to solve the problem of finger occlusion and improve the interactive experience, Sun Guodao et al. [4] proposed a method of setting dual Leap Motion at different angles, which has a significant effect on reducing finger aliasing and improving ease of use. In view of the shortcomings of automatic geometry-driven virtual cultural relics splicing, Lu Haoran et al. [5] proposed a method for implementing fragmentation and splicing using Leap motion. The traditional virtual plant human-computer interaction system generally runs on a specific operating system or mobile platform, and the interaction mode mostly involves human-computer interaction through the mouse and keyboard, which requires users to input more cumbersome parameters and commands, resulting in a lack of good interactive experience for system users. In view of the above situation, Wu Fuli et al [6] designed and developed a virtual crop somatosensory interaction system based on cloud computing and somatosensory interaction technology.

In foreign countries, Catalin et al [7] proposed a new five-finger humanoid gripper command and control scheme based on leap motion sensor, which is used in industrial machines to achieve low complexity and medium complexity. Manawadu et al. [8] developed an operator interface for a driver's vehicle based on Leap motion sensors, which sends commands to the car through gesture interaction to achieve automatic driving. Aashni Haria et al. [9] designed a robust marker-free gesture recognition system based on leap motion, which can effectively track static and dynamic gesture systems and improve the human-computer interaction experience. Haiyang et al. [10] used a new type of tracking sensor, Leap motion, to perform a non-contact demonstration of the robot.

In summary, Leap motion has a wide range of applications. In the process of human-computer interaction, the Leap motion sensor acts as a “bridge” between people and machines. By introducing Leap motion into Science exhibition, it helps to improve the user's interactive experience in Science exhibition. At present, the development and design of Leap motion is only to achieve the technical level of implementation, and does not establish a unified system design theory. By proposing a Science exhibition interactive system based on Leap motion, a user-centered system design theory is provided as a reference for the design and development of Leap motion.

3. Design of interactive exhibition system for science exhibits based on Leap motion

The Science exhibition interactive system based on Leap motion is mainly based on the user experience to improve the user's interactive experience. In the design of interactive systems, the scenes of science exhibition are mainly science and technology museums, museums and schools. Users usually include expert users and beginners. Science exhibits are the carriers of popular science content. The interactive method is the most important channel for users to obtain popular science content. The interactive system design is shown in Figure 2.
3.1. User layer
The user's proficiency in Leap motion can be divided into beginner users and expert users. The beginner user refers to the user who is used for the first time and is in the exploration stage, while the expert user refers to the cognitive and familiarity of the gesture interaction of Leap motion. Beginner users are not proficient in operation, resulting in unstable Leap motion recognition, which easily affects the user's interactive experience. Beginner users can continue to practice to reach the level of expert users.

3.2. Environmental layer
The Science and Technology Museum is a place for users to learn popular science knowledge. The use of Leap motion somatosensory equipment requires consideration of the environment. The science and technology museum has a large flow of people and the use of equipment is relatively frequent, so the stability of Leap motion sensing device identification is an important factor to enhance the user experience. Considering the special nature of the Science and Technology Museum, Leap motion needs to maintain high recognition performance.

3.3. Interaction layer
The gesture interaction of Leap motion is more and more complex, and the interactive experience is not obvious enough. Create a simple gesture interaction library and define related interaction events. Users can complete simple and correct interactions and improve the recognition performance of Leap motion, further enhancing the user experience. The design of the gesture interaction library is shown in Table 1.

| Gesture interaction library | Definition of event |
|-----------------------------|---------------------|
| Gesture 1                   | Click               |
| Gesture 2                   | Rotate              |
| Gesture 3                   | Zoom                |
| Gesture 4                   | Grab                |
| Gesture 5                   | Mobile              |
| ...........                 | ...........         |

Table 1. Gesture interaction library
3.4. Carrier layer
The main function of the Science exhibition is to show the science to the audience, popularize the scientific knowledge, and display the scientific knowledge vividly and visually [11]. Traditional science exhibits are books, exhibition boards, and models. They are usually only for users to learn and refer to. This interactive mode is that the user is in a passive receiving state, and the user can only passively accept the feedback of the popular science exhibits, so the user is interested in the traditional science exhibits. The cost of learning increases, as shown in Figure 3.

![Figure 3. Traditional interactive mode of Digital science exhibits](image)

With the continuous development of Internet technology, science exhibits gradually shift from traditional exhibits to digital science exhibits. The advancement and transformation of technology introduces various interaction methods, further enhancing the user's experience of popular science exhibits. Users can use their body language to interact with the exhibits in a spatial manner. This form of interaction allows the user's sense of participation and experience to be more satisfied [12]. The development of interactive design of popular science exhibits is closely related to interactive technology [13]. Somatosensory interaction technology is an important interactive technology to meet the design of interactive products centered on “people”. For science exhibits, interaction is the most important part of the popular science experience [14]. Through the improvement of interactive technology, the user's interactive experience can be improved. Digital science exhibits mainly include mobile and PC. Users can interact in two-dimensional and three-dimensional ways. This interaction is two-way. Users input interactive behavior through Leap motion. Leap motion sends commands to PC, digital science exhibits. Feedback to the user in a timely manner, the user proceeds to the next operation based on feedback, as shown in Figure 4.

![Figure 4. The interactive mode between leap motion and Digital science exhibits](image)

4. “Planet Story” Science Exhibition Interactive System Design Case
The Unity3D platform was used to build the scene by combining the “Planet Story” project of the Science and Technology Museum of Guizhou Province with Leap motion.

Step 1, install the Leap motion SDK development environment and connect the Leap motion sensing device to the PC. If it is green, the connection is normal.

Step 2, the planet is created by adding a map to the sphere model, and the sun is created by means of textures and particle effects, forming a solar system.
Step 3, import the plugin developed by Leap motion in unity3D. Calls are made using the gesture control class of Leap motion.

4.1. Interaction design of the main scene
In the main scene, the principle of emitting rays is used to pick up the planets to solve the lack of interactive experience of Leap motion in the three-dimensional scene. Taking the Earth as an example, by clicking on the ray, you can rotate, zoom, and “long press” clicks on the earth. Enter the Earth's secondary scene interface by clicking on the Earth, as shown in Figure 5.

![Initialized scene](image1)
![Launching a ray for grabbing](image2)
![Grab the earth](image3)
![Rotating earth](image4)
![Zooming the earth](image5)
![“Long press” Click](image6)

**Figure 5. Interaction case of main scene**

4.2. Interaction design of secondary scenes
In the secondary interface of the Earth, a two-dimensional scene interface is built. Gestures can directly trigger the UI interface, generate UI interaction effects by clicking, and pop up the corresponding UI menu for introduction. You can rotate the earth by swiping left and right by gestures, as shown in Figure 6.

![Entering the earth secondary interface](image7)
![Click on UI - Animal Introduction](image8)
5. User Evaluation of “Planet Story” Science Exhibition Interactive System

In this experiment, 50 users were selected for experiments, and tested according to three indicators of interactive experience: realism level, learning stress level and user pleasure level. The level is -3~3, the closer to -3, the smaller the level, the weaker the indicator. Conversely, the closer to 3, the greater the rating, the stronger the indicator of performance. The number of people at each level is displayed by selecting each level by 50 users. To verify the effectiveness of Leap motion in the Science exhibition interactive system by analyzing the two sets of data using Leap motion device and no interactive device, the formula of three indicators: Effect(Total)=index(positive)+index(negative).

5.1. User interaction realism evaluation
Table 2. User interaction realism evaluation

| realism level | Leap motion (number of people) | None (number of people) |
|---------------|-------------------------------|-------------------------|
|               | Click | Rotate | Zoom | Grab | Click | Rotate | Zoom | Grab |
| -3            | 2     | 5      | 1    | 1    | 10    | 11     | 15   | 20   |
| -2            | 6     | 3      | 2    | 3    | 8     | 9      | 7    | 12   |
| -1            | 7     | 8      | 3    | 2    | 7     | 10     | 8    | 8    |
| 0             | 4     | 4      | 6    | 5    | 6     | 7      | 5    | 6    |
| 1             | 6     | 6      | 8    | 5    | 5     | 6      | 6    | 2    |
| 2             | 10    | 8      | 10   | 16   | 7     | 5      | 5    | 1    |
| 3             | 15    | 16     | 20   | 18   | 7     | 2      | 4    | 1    |
| Trueness      | 16    | 14     | 32   | 33   | -6    | -17    | -15  | -36  |

According to the data in Table 2, Trueness (Leap motion)>Trueness(none), which is used in Science exhibition by Leap motion, can enhance the realism of user interaction.

5.2. User Learning Stress Assessment

Table 3. User Learning Stress Assessment

| Learning stress level | Leap motion (number of people) | None (number of people) |
|-----------------------|-------------------------------|-------------------------|
|                       | Click | Rotate | Zoom | Grab | Click | Rotate | Zoom | Grab |
| -3                    | 12    | 15     | 16   | 14   | 1     | 6      | 3    | 2    |
| -2                    | 10    | 12     | 10   | 11   | 5     | 8      | 4    | 3    |
| -1                    | 8     | 6      | 7    | 6    | 7     | 5      | 6    | 7    |
| 0                     | 5     | 3      | 3    | 4    | 3     | 2      | 5    | 6    |
| 1                     | 3     | 6      | 8    | 5    | 7     | 6      | 7    | 4    |
| 2                     | 7     | 5      | 4    | 6    | 12    | 13     | 9    | 15   |
| 3                     | 5     | 3      | 2    | 4    | 15    | 10     | 16   | 13   |
| Pressure              | -15   | -19    | -19  | -16  | 11    | 10     | 19   | 20   |

According to the data in Table 3, Pressure(Leap motion)<Pressure(none), which is used in Science exhibition by Leap motion, which can reduce the user's learning pressure.

5.3. User pleasure assessment

Table 4: User pleasure assessment

| Pleasure level | Leap motion (number of people) | None (number of people) |
|---------------|-------------------------------|-------------------------|
|               | Click | Rotate | Zoom | Grab | Click | Rotate | Zoom | Grab |
| -3            | 3     | 6      | 2    | 3    | 13    | 16     | 12   | 15   |
| -2            | 5     | 9      | 3    | 2    | 11    | 13     | 14   | 12   |
| -1            | 7     | 4      | 7    | 8    | 7     | 4      | 6    | 7    |
| 0             | 5     | 4      | 8    | 6    | 4     | 3      | 6    | 3    |
| 1             | 6     | 3      | 5    | 2    | 5     | 6      | 4    | 5    |
| 2             | 10    | 11     | 10   | 13   | 6     | 3      | 5    | 3    |
| 3             | 14    | 13     | 15   | 16   | 4     | 5      | 3    | 5    |
| Pleasure      | 15    | 8      | 18   | 18   | -16   | -19    | -20  | -11  |

According to the data in Table 4, Pleasure (Leap motion)>Pleasure(none), which is used in Science exhibition by Leap motion, can improve the user's pleasure.
6. Conclusion

Science exhibition is an important way for viewers to understand the contents of popular science. By introducing Leap motion gesture recognition technology to interact, the user's realism in the interactive system is enhanced, the user's learning cost is reduced, and the user's participation in the process is improved. The interactive development of Science exhibition injects new forms of interaction. While the Leap motion device improves the single, boring interactive experience of the past, the Leap motion sensing device limits the number of participants, and is used by only one user at a time. In the future development, increase the number of people involved in Leap motion, so that more users can participate at the same time.

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References
[1] YANG Jian, CHEN Yang, WANG Dan-dan, ZHONG Fang-xu. Research on interactive interface design of popular science exhibits based on emotional concept[J]. Packaging Engineering, 2016, 37(06): 109-113.
[2] Li Yinghui, Shi Zhuo, An Yalei. Three-dimensional gesture recognition method based on Leap Motion[J]. Modern Computer (Professional Edition), 2016(14):74-76+80.
[3] Mou Yunhuan. Design and implementation of virtual sand painting display system based on gesture recognition[J]. Electronic Design Engineering, 2018, 26(20):169-173.
[4] Sun Guodao, Huang Puyong, Liu Yipeng, Liang Ronghua. Research on 3D Visualization Interaction Method Based on Double Leap Motion[J]. Journal of Computer-Aided Design & Computer Graphics, 2018, 30(07):1268-1275.
[5] LU Haoran, ZHANG Yu, NIU Miaomiao, TAI Wuyang, ZHOU Mingquan. A virtual mosaic method for 3D artifacts based on Leap motion[J]. Journal of System Simulation, 2015, 27(12): 3006-3011+3017.
[6] Wu Fuli, Ding Wei, Ding Weilong, Xie Tao. Design of virtual crop human-computer interaction system based on Leap Motion[J]. Transactions of the Chinese Society of Agricultural Engineering, 2016, 32(23): 144-151.
[7] Catalin Constantin Moldovan, Ionel Staretu. An Anthropomorphic Hand with Five Fingers Controlled by a Motion Leap Device [J]. Procedia Engineering, 2017, 181.
[8] Manawadhu U E, Kamezaki M, Ishikawa M, et al. A hand gesture based driver-vehicle interface to control lateral and longitudinal motions of an autonomous vehicle [C] / IEEE International Conference on Systems, Man, and Cybernetics. IEEE, 2016: 001785-001790.
[9] Ashini Haria, Archanasri Subramanian, Nivedhitha Asokkumar, Shristi Poddar, Jyothi S Nayak. Hand Gesture Recognition for Human Computer Interaction [J]. Procedia Computer Science, 2017, 115.
[10] Haiyang Jin, Qing Chen, Zhixian Chen, Ying Hu, Jianwei Zhang. Multi-LeapMotion sensor based demonstration for robotic refine tabletop object manipulation task[J]. CAAI Transactions on Intelligence Technology, 2016, 1(1).
[11] Liang Henglong. Analysis of the function and form of science exhibits[J]. Science and Technology, 2015(04):41.
[12] Peng Mengjun, Peng Li. Research on the design of popular science exhibits integrating augmented reality and user experience. Design. 2018.
[13] Yan Jingyan. Research on the Influence of Artificial Intelligence on Interaction Design[J]. Packaging Engineering, 2017, 38(20): 27-31.
[14] TAN Jie, HAN Jinhong, YANG Tao, WANG Jingchun. Design and Implementation of Internet-based Remote Operation and Experience System for Science Exhibitions[J]. Experimental Technology and Management, 2016, 33(09): 134-136.