

A Cloud Exhibition Hall System of Extended Reality Using Apriori Algorithm

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Abstract: Traditional exhibition halls have many disadvantages, and the exhibition effect is not ideal. For example, large equipment cannot be transported and displayed due to the limitation of display space and cost, and it is difficult to convey the use scenario and experience of products to customers; Offline exhibition booths are limited, so more products cannot be displayed, and high-end products are not convenient to enter the site; For the raw materials, functions, structures, and specifications of products, there is a lack of real application cases to show the products; The cost of field investigation is high. If the process, production line, and production capacity cannot be investigated in depth, the customer cannot be trusted. Given Because of the numerous pain points in traditional exhibition halls, this paper proposes an XR display method based on the Apriori algorithm. Through this method, a cloud exhibition hall system is designed and implemented, which can effectively solve the problems of limited space in traditional exhibition halls, single exhibition means, inability to display the details of exhibits, inability to effectively collect customer opinions, and inability to mine and analyze customer data. The experiment shows that the system can feel the pain points of traditional exhibition halls, improve the exhibition effect of exhibition halls, and better promote the promotion of products.

Keywords: Apriori, exhibition hall, Extended Reality, system, Unity

1. Introduction

There are many pain points in traditional display: for example, large equipment cannot be transported for display due to the limitation of display space and cost, and it is difficult to convey the use scenario and experience of products to customers^[1]; Offline exhibition booths are limited, so more products cannot be displayed, and high-end products are not convenient to enter the site; For the raw materials, functions, structures and specifications of products, there is a lack of real application cases to show the products; The cost of field investigation is high, and it is impossible to deeply investigate the process, production line and capacity, which cannot be trusted by customers; In terms of exhibition content, due to the single means of exhibition and presentation, and the unified classification and division of parts, it is impossible to cross present, which easily leads to the fragmentation of the exhibition content, which makes the audience unable to form a deep memory when visiting the exhibition hall, which is not conducive to the audience's appreciation and experience; In terms of exhibition form, static display mode can hardly arouse the interest and curiosity of the audience, and can not let the audience interact with the exhibits, which makes people feel distant from the exhibition hall, and it is difficult to have emotional resonance with the exhibition hall, and also can not seriously watch the exhibition; In terms of visitors' experience, the traditional exhibition is a one-way indoctrination of information, which leads to a weak sense of experience of the audience, so that they have no good impression on the exhibition hall. At this stage, 5G technology and XR technology have become mature, and supporting the development of traditional industries in the direction of networking, digitalization and intelligence has become the current need. It is extremely urgent to hold cloud exhibitions by making full use of modern information technology. Moreover, the enterprise's strength and product services in the traditional exhibition hall display have not been fully expressed, so the customer's understanding of the enterprise is not enough. The appearance of the XR technology display can make the enterprise display more brilliant^[2].

2. Industry Status

The cloud exhibition hall is still in its infancy, but it has a good momentum of development. At present, there is no complete and successful model to imitate and learn from, and the leading enterprises in the industry have not yet emerged. At present, cloud exhibition is more about moving traditional exhibitions to the Internet. The lack of high-quality exhibition talents and professional exhibition enterprises, as well as a set of effective XR display systems, can not only solve the shortcomings of traditional display in terms of space, appearance, and other issues but also conduct statistics and analysis of relevant data, to obtain effective reference data, which can enable enterprises to further optimize product display points, to more effectively promote the products of various manufacturers, so that visitors can better understand the products, Expand the influence of enterprise products^[3].

3. Apriori Algorithm Scheme Design

The Apriori algorithm is the most influential algorithm for mining frequent itemsets of Boolean association rules. It was proposed by Rakesh Agrawal and Ramakrishnan Srikant. It uses an iterative method called layer-by-layer search^[4]. The k-itemset is used to explore the (k+1) - itemset. First, find the set of frequent 1-itemsets^[5]. This set is recorded as L1. L1 is used to find the set L2 of frequent 2-itemsets, while L2 is used to find L2, and so on until k-itemsets cannot be found. Every time you find an Lk, you need to scan the database. To improve the efficiency of generating frequent itemsets layer by layer, an important property called the Apriori property is used to compress the search space. Its operation theorem is that one is that all non-empty subsets of frequent itemsets must also be frequent, and the other is that all parent sets of non-frequent itemsets are non-frequent. The Apriori algorithm can integrate effective data^[6]. The cloud exhibition hall needs to summarize and analyze all kinds of data, mine the association rules between data, and finally obtain important data, so as to provide effective reference suggestions for the enterprises deploying the exhibition. The specific algorithm design is shown in Fig. 1.

```

1)  $L_1 = \{\text{large 1-itemsets}\};$ 
2) for (  $k = 2; L_{k-1} \neq \emptyset; k++$  ) do begin
3)    $C_k = \text{apriori-gen}(L_{k-1});$  // New candidates
4)   forall transactions  $t \in \mathcal{D}$  do begin
5)      $C_t = \text{subset}(C_k, t);$  // Candidates contained in  $t$ 
6)     forall candidates  $c \in C_t$  do
7)        $c.\text{count}++;$ 
8)     end
9)    $L_k = \{c \in C_k \mid c.\text{count} \geq \text{minsup}\}$ 
10) end
11)  $\text{Answer} = \bigcup_k L_k;$ 

```

Figure 1: The specific algorithm design

4. Implementation of XR Cloud Exhibition Hall System

4.1. Development Tools

4.1.1. Unity

Unity is a multi-platform game development engine developed by Danish Unity Technologies, which is a fully integrated professional game production tool. Its biggest feature is its excellent platform flaunting. The game software or virtual reality system produced by Unity is released on PC, Mac, Android, and mainstream home game console platforms launched by Microsoft, Nintendo, and Sony. Once launched, it has been favored by game and virtual reality developers and has become a 3D production engine with rapid development in recent years. In addition, Unity can also be used to develop display systems based on virtual reality technology and is widely used in tourism, medicine and other

fields^[7]. The Unity development platform is shown in Fig. 2.



Figure 2: The Unity development platform

4.1.2. Maya

Maya is the world's top 3D animation software produced by Autodesk Company in the United States. Its application objects are professional film and television advertisements, character animation, film stunts, etc. Maya is a high-end movie production software with complete functions, flexible work, high production efficiency, and strong rendering realism. Maya integrates the most advanced animation and digital effects technologies of Alias and Wavefront^[8]. It not only includes general 3D and visual effects production functions, but also combines with the most advanced modeling, digital cloth simulation, fur rendering, and motion matching technologies. Maya runs on Windows NT and SGI IRIX operating systems. Maya is the preferred solution for digital and 3D production tools on the market. The Maya work interface is shown in Fig. 3.

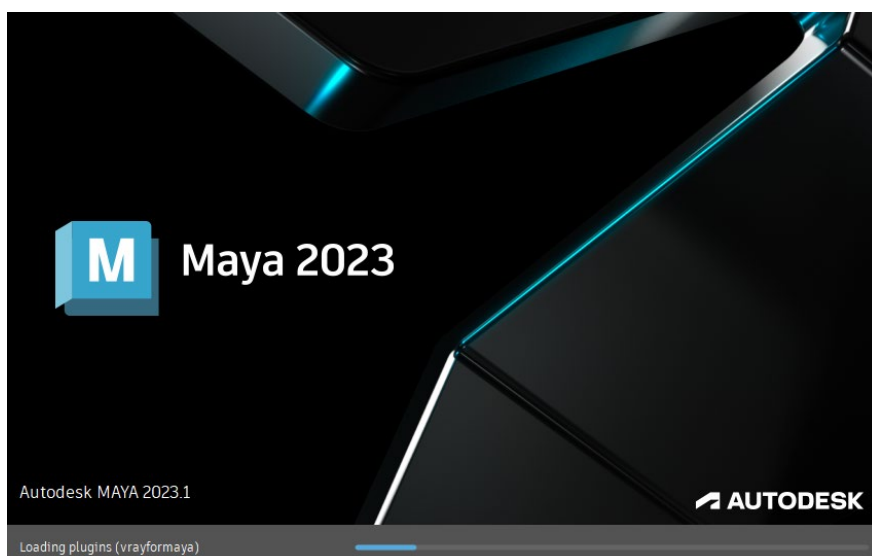


Figure 3: The Maya work interface

4.2. System Realization

The system design is divided into four parts: basic model library, interactive function module, data analysis module, and UI design^[9]. Specific development process: First, the Maya engine is used to build the basic model library, the Unity engine is used to develop various interactive function modules, the Apriori algorithm is integrated into the data analysis module, and finally all kinds of UIs required by the system are completed, and the system is released to VR, Web, PC, and mobile phones^[10]. The System architecture diagram is shown in Fig. 4.

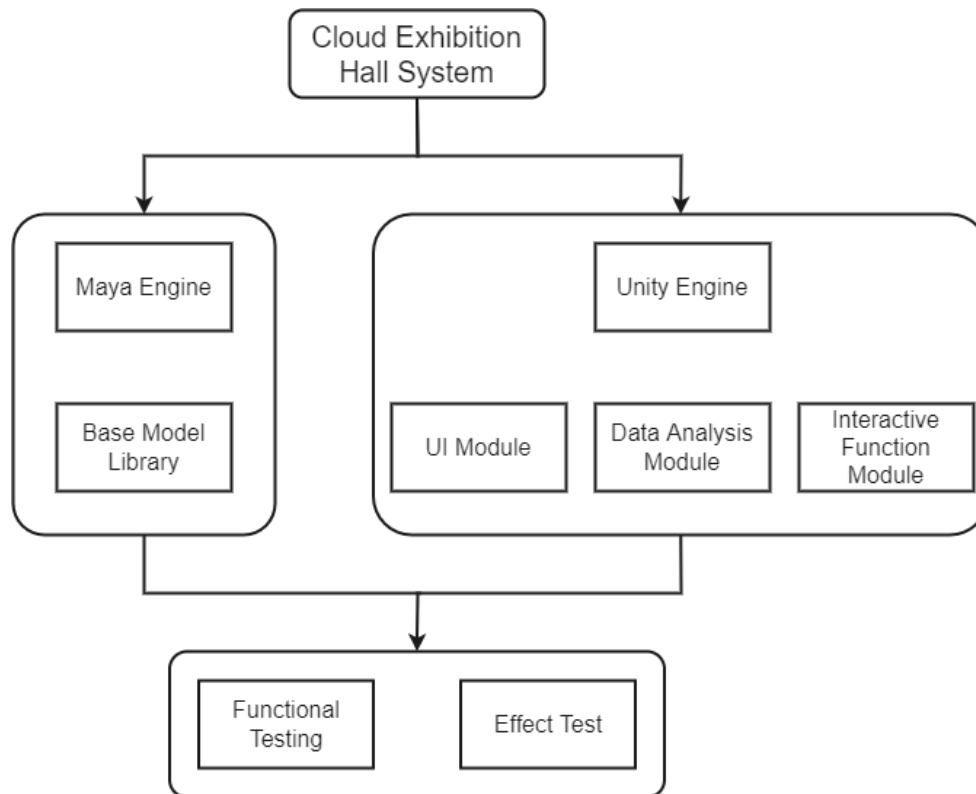


Figure 4: The System architecture diagram

4.2.1. Basic Model Library

Since the unit in Unity is meters, and the unit ratio of Unity and Maya is 100:1, in order to facilitate the import of the model into Unity for system development in the future, first set the system unit ratio and display the unit ratio of Maya software to centimeters, and then model according to the design of the exhibition hall. During modeling, the emphasis is on grasping the size ratio of the model, which must be consistent with the size ratio of the real world^[11]. The following points should be paid attention to when modeling:

(1) In order to improve the operation efficiency of the system, the number of faces of the model should be reduced as far as possible and the invisible faces and redundant vertices in the model should be deleted^[12].

(2) There shall be no overlapping surfaces and broken surfaces between models.

(3) Adjust the model pivot as required.

(4) The naming of models and materials must be in English^[13]. A good Maya model needs to be exported to the FBX format with the help of plug-ins. When exporting, you need to pay attention to setting the up axis as the Y axis^[14]. This is mainly because the default Y axis in Unity is up. The basic model library is shown in Fig. 5.

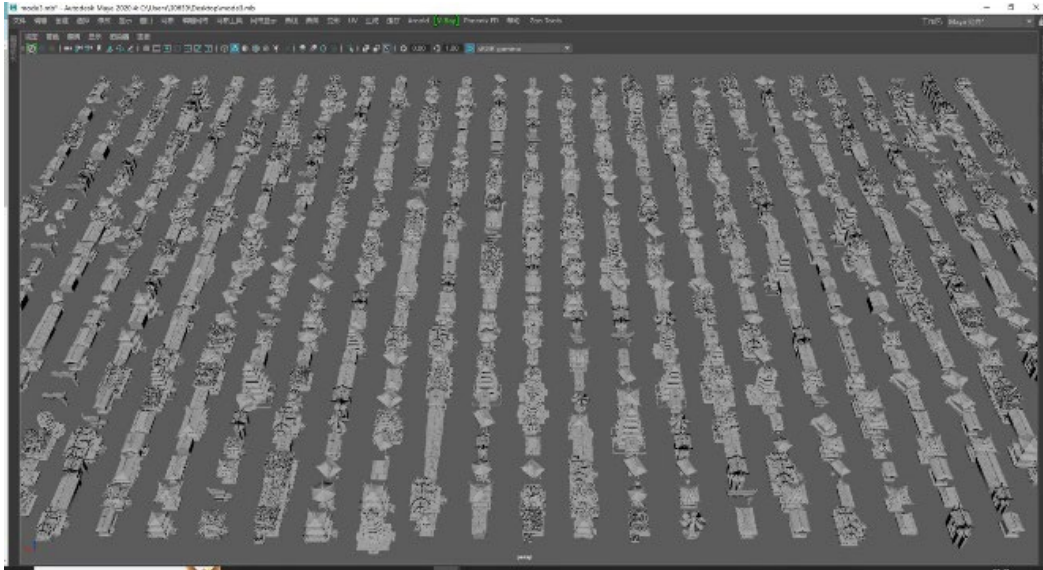


Figure 5: The basic model library

4.2.2. Mapping of Basic Model Library

The production of maps is generally synchronized with the production of the exhibition hall model^[15]. In order to optimize the system performance as much as possible, many details of the exhibition hall need to be represented by maps. For example, the floor texture of the exhibition hall is depicted by maps^[16]. The mapping of the model generally requires UV unwrapping through Maya, and then the mapping is completed in Photoshop^[17]. In order to improve the system performance, it is necessary to minimize the number and amount of maps. This is because each shader uses a map when it is finally imported into Unity. The more maps you have, the more shaders you need for material representation^[18]. In the same scene model, the more shaders you need, the worse the system performance. To reduce the use of maps, you need to merge them. The principle of merging is that the maps of the same material can be merged together. At this time, you only need to make the diffuse map of the model, that is, the texture map^[19]. The effects of reflection and refraction need to be completed in Unity.

4.2.3. Interactive Module Development

The exhibition hall scene roaming mainly realizes various types of control based on keyboard, VR handle, mobile phone touch screen, and so on, allowing users to browse freely in the virtual exhibition hall scene through the first person way^[20]. Among them, the controllable first-person game object is a game object with a Character Controller component, an Audio Source component^[21], and a Camera sub-object, which can walk freely through scripts. With the Character Controller component, you can control the movement of this game object, and with the Audio Source component, you can hear the sound effect in the scene and the sound of student animation works in real-time^[22]. The system realizes the rotation and movement functions. The first-person movement is completed by the SimpleMove() method of the CharacterController component, and the first-person rotation is completed by the Rotate() method of the Transform component^[23]. The interactive display of the product mainly realizes the collision detection of the first-person game object controlled by the user to the animation works and the playback of the animation^[24]. The products are stored in the form of an array, and the objects in the collision scene are determined by the collision detection of the trigger, and the corresponding products of the collision objects are detected circularly^[25]. The product splitting, rotation, translation, and other functions are controlled by clicking the image buttons with the mouse, VR handle, or touch screen. The codebase is shown in Fig. 6.

This system includes three scenarios: system start scenario, system setup scenario, and exhibition hall scenario^[26]. The system first enters the system start scenario and then clicks the button to enter the other two scenarios^[27]. Each interface element, such as the background and button, is imported into Unity as an independent image. Build the interface through GUITexture in Unity, and load the scene through a script. For the sake of a beautiful interface, this scene uses a custom skin^[28]. When the system starts running, it only loads the start scenario of the system and then downloads other scenarios from the background according to the user's operation^[29]. The Application is adapted The GetStreamProgressForLevel() method downloads the scene in the stream mode. After downloading from the background in the stream mode, you can use the Application LoadLevel() load the downloaded scene.

By loading in the stream mode, the system can run without loading all files^[30]. When the first scene is loaded, the system can run, and automatically loads the second scene from the background.

```

52 // Miscellaneous Files
53 // Summary
54 public enum AbilityBoolOverride
55 {
56     NoOverride, // The ability should not override the value.
57     True, // The ability should set the value to true.
58     False, // The ability should set the value to false.
59 }
60 [Tooltip("Can the ability be activated?")]
61 [SerializeField] protected bool m_Enabled = true;
62 [Tooltip("Specifies how the ability can be started.")]
63 [HideInInspector] [SerializeField] protected AbilityStartType m_StartType = AbilityStartType.Automatic;
64 [Tooltip("Specifies how the ability can be stopped.")]
65 [HideInInspector] [SerializeField] protected AbilityStopType m_StopType = AbilityStopType.Manual;
66 [Tooltip("The button name(s) that can start or stop the ability.")]
67 [HideInInspector] [SerializeField] protected string[] m_InputNames;
68 [Tooltip("Specifies how long the button should be pressed down until the ability starts/stops. Only used when the ability has a start/stop type of LongPress.")]
69 [SerializeField] protected float m_LongPressDuration = 0.5f;
70 [Tooltip("Should the long press wait to be activated until the button has been released?")]
71 [HideInInspector] [SerializeField] protected bool m_WaitForLongPressRelease;
72 [Tooltip("Optionally specify an attribute that the ability should affect when active.")]
73 [HideInInspector] [SerializeField] protected Traits.AttributeModifier m_AttributeModifier = new Traits.AttributeModifier();
74 [Tooltip("Specifies the name of the state that the ability should use when active.")]
75 [HideInInspector] [SerializeField] protected string m_State;
76 [Tooltip("Should the state name be appended to the name of the state name?")]
77 [HideInInspector] [SerializeField] protected bool m_StateAppendTypeName;
78 [Tooltip("Specifies the value to set the ability index parameter. (-1 will not set the parameter.)")]
79 [HideInInspector] [SerializeField] protected int m_AbilityIndexParameter = -1;
80 [HideInInspector] [SerializeField] protected AudioClipSet m_StartAudioClipSet = new AudioClipSet();
81 [Tooltip("A set of AudioClips that can be played when the ability is started.")]
82 [HideInInspector] [SerializeField] protected AudioClipSet m_StopAudioClipSet = new AudioClipSet();
83 [Tooltip("Does the ability allow positional input?")]
84 [HideInInspector] [SerializeField] protected bool m_AllowPositionalInput = true;
85 [Tooltip("Does the ability allow rotational input?")]
86 [HideInInspector] [SerializeField] protected bool m_AllowRotationalInput = true;
87 [HideInInspector] [SerializeField] protected bool m_AllowOptionalInput = true;
88 [Tooltip("Should the character use gravity while the ability is active?")]
89 [HideInInspector] [SerializeField] protected AbilityBoolOverride m_UseGravity = AbilityBoolOverride.NoOverride;
90 [Tooltip("Can the character use root motion for positioning?")]
91 [HideInInspector] [SerializeField] protected AbilityBoolOverride m_UseRootMotionPosition = AbilityBoolOverride.NoOverride;
92 [Tooltip("Can the character use root motion for rotation?")]
93 [HideInInspector] [SerializeField] protected AbilityBoolOverride m_UseRootMotionRotation = AbilityBoolOverride.NoOverride;
94 [Tooltip("Should the character detect horizontal collisions while the ability is active?")]
95 [HideInInspector] [SerializeField] protected AbilityBoolOverride m_DetectHorizontalCollisions = AbilityBoolOverride.NoOverride;
96 [Tooltip("Should the character detect vertical collisions while the ability is active?")]
97 [HideInInspector] [SerializeField] protected AbilityBoolOverride m_DetectVerticalCollisions = AbilityBoolOverride.NoOverride;
98 [Tooltip("A reference to the Animator that the ability uses.")]
99 [HideInInspector] [SerializeField] protected AnimatorMotion m_AnimatorMotion;
100 [Tooltip("A mask specifying which slots can have the item equipped when the ability is active.")]
101 [HideInInspector] [SerializeField] protected int m_AllowEquippedSlotsMask = -1;
102 [Tooltip("Should the ability equip the slots that were equipped when the ability started?")]
103 [HideInInspector] [SerializeField] protected bool m_RequireSlots = true;
104 [Tooltip("The text that should be shown by the message monitor when the ability can start.")]
105 [HideInInspector] [SerializeField] protected string m_AbilityMessageText;
106 [Tooltip("The sprite that should be drawn by the message monitor when the ability can start.")]

```

Figure 6: The codebase

4.2.4. Optimization of The Exhibition Hall

(1) Use of light mapping technology. In order to increase the reality of the system, it is necessary to generate shadows of objects, but real-time shadows will consume a lot of system resources^[31]. In order to improve the performance of the system, for a large number of immovable objects in the scene, you can use the light mapping technology in Unity^[32]. For example, the trees in the scene outside the exhibition hall can write the shadow information of the scene to the corresponding file through lightmap (lightmap technology) in Unity, which can be called in real-time during the running of the scene, saving a lot of system resources. The main light source of the exhibition hall scene of this system is Directional Light^[33]. First, check whether there is a suitable UVs for positioning the lightmap on the model to be baked. If not, you can generate a set for positioning the lightmap UVs by checking the Generate Lightmap UVs option in the mesh import settings panel; Secondly, set the object to baking the lightmap to Static on the object panel^[34], so that Unity will know which objects need to be baked; Select Window -> Lightmapping to open the light mapping tool window for setting, click Bake, and wait until the baking is completed^[35].

(2) Use of occlusion elimination technology. Occlusion Culling: When occlusion culling is used, hidden faces or hidden objects that will not be seen due to occlusion will be culled before the rendered objects are sent to the rendering pipeline^[36], thus reducing the amount of rendering data per frame and improving rendering performance. For this virtual exhibition hall, the camera cannot see all the scenes in every frame, so occlusion culling technology can be used for optimization^[37]. The exhibition hall scene of this system applies occlusion elimination technology, setting small objects or transparent objects in the scene as Occlusions Static, and other static objects as Occlusion Static. The system rendering is shown in Fig. 7.



Figure 7: The system rendering

5. XR Cloud Showroom System Experiment and Evaluation

5.1. Experimental Environment and Preparation

5.1.1. Preparation of Multi-terminal Equipment

As the system finally released VR, Web, PC, and mobile phones^[38], the experimental environment needs to prepare PICO all-in-one machines, high-performance computers, mobile phones, and other equipment^[39]. For the future high applicability of the system, all terminal devices use mainstream products in the market as the experimental environment.

5.1.2. Test Plan

This experiment test is mainly divided into three modules: performance optimization test module, XR experience comfort test module^[40], and data analysis rationality test module.

5.2. Analysis and Evaluation of Experimental Test Results

5.2.1. Performance Optimization Test

Run the system and other similar products on the equipment with the same configuration^[41], and count the average FPS (frame rate), the highest FPS, the lowest FPS, and other values of each product during operation. As shown in Table 1, the average FPS, the highest FPS, the lowest FPS, and other data of this system are all ahead of other similar products. It can be seen that the performance optimization of this system is significantly higher than that of similar products.

Table 1: Performance Optimization Test

Class	Average FPS	Highest FPS	Minimum FPS
This software	78	90	75
Similar software 1	65	75	58
Similar software 2	60	70	55
Similar software 3	70	76	57
Similar software 4	72	78	56
Similar software 5	69	77	59

5.2.2. XR Experience Comfort Test

During the test, we invited 4 groups of people of different ages to wear the head display device for experience^[42], ran the system and other similar products on the same head display device, and recorded the feedback of each group of experienced personnel^[43]. As shown in Table 2, all groups of experienced personnel indicate that the experienced comfort of this system is the best.

Table 2: XR Experience Comfort Test

Class	This software (comfort)	Similar software1 (comfort)	Similar software2 (comfort)	Similar software3 (comfort)
12-18 years old	100	90	88	89
19-30 years old	98	88	85	82
31-45 years old	95	85	83	78
46-60 years old	94	80	78	70

5.2.3. Data Analysis Rationality Test

By integrating the Apriori algorithm, the system will analyze the information data of each experience^[44], mine association rules through the algorithm, and draw more scientific analysis conclusions^[45]. Through one-to-one comparison with the experienter data, as shown in Table 3, the conclusions of the data analysis of the system are highly consistent with the feedback information of the experience, which shows that the data analysis of the system is highly reasonable, The analysis results provided have very high reference value^[46].

Table 3: Data Analysis Rationality Test

Class	Analysis results of this software	Experience feedback	Consistent
Most interesting content	V10, V08	V10, V08	Yes
Favorite interaction mode	V01	V01	Yes
Products willing to buy	V06	V06	Yes
Products you want to know more about	V02	V02	Yes
Products not interested	V09	V09	Yes

6. Conclusions

This paper proposes an XR display method based on the Apriori algorithm. Through this method, a cloud exhibition hall system is designed and implemented, which effectively solves the problems of traditional exhibition halls that are limited by display space and cost, lack of real application cases of display products, single display means, and inability to display the details of exhibits. Through detailed comparative experimental tests, the experimental results show that this system can solve the problems of traditional exhibition halls. Compared with similar products, it also has better performance optimization, better experience comfort, and high reference value of experimenter data analysis report. Therefore, the system can help enterprises to improve the exhibition hall display effect and better promote the promotion of products.

Acknowledgment

Vision VR - Cloud Exhibition Hall, Project(ZJDFC-HX2022009).

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