



3DMAX-Powered Virtual Reality Solutions for Interactive Architectural Landscape Roaming Design

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Abstract. An interactive architectural garden landscape roaming design technique based on 3DMAX is proposed to address the issue that 3DMAX software can only display static 3D images and cannot realise interactive architectural garden landscape roaming. The method combines the three platforms of 3DMAX, Photoshop and Java3D to achieve the following steps: basic information collection and scene design presetting of architectural landscape: firstly, basic information of architectural landscape is collected, and scene design and downscaling presetting are carried out. 3DMAX platform modelling and rendering: basic modelling, material mapping, lighting rendering and camera setting of architectural landscape are carried out on the 3DMAX platform. The 3D visualization modeling is realized through steps such as lighting rendering and camera settings. Photoshop platform texturing: the scene materials are edited and the interface is created using the Photoshop platform to realize the texturing of the architectural landscape. Viewpoint transformation formula combined with Java3D technology: Combining the viewpoint transformation formula with Java3D technology to design an interactive architectural landscape roaming algorithm. interactive roaming implementation on Java3D platform: Using the algorithm to set up behavioral scripts and paths on the Java3D platform to implement interactive roaming. The method was tested on Windows 10 and the results showed that the method meets the needs of interactive roaming of architectural landscapes with a simple operating interface and good roaming results. By combining 3DMAX, Photoshop and the Java3D platform, the method can overcome the limitations of the 3DMAX software and achieve interactive roaming of architectural landscapes, providing a better roaming experience for designers and users.

Keywords: interactive roaming; autonomous mode setting; garden landscape; roaming design; information collection; visual modeling; Virtual Reality Solutions.

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1 INTRODUCTION

Landscape design is an important branch of architectural outdoor design, through the professional design and technology of garden art, the use of vegetation types, garden paths and other methods to transform the environment of architectural space, to create garden art in harmony with the space and human environment, so that the designed architectural space meets human aesthetic and cultural needs, and meets the function of daily life to achieve ecological sustainability [19]. Indirectly reflecting the value direction of societal evolution, architectural landscape design also reveals the aesthetic notion of the designer. The ecological environment is degrading as a result of the ongoing growth of technology and civilization, and people are becoming more and more concerned with the sustainable development of architectural landscape design[3]. With the advancement of 3DMAX technology, in particular, people are paying more attention to the interaction of architectural landscape design, according to experts and academics [4]. A variety of strategies have been included by designers into the 3DMAX software to provide architectural landscape design solutions and final effects visualised in the 3DMAX software, offering flawless architectural landscape design solutions[17]. In recent years, interactive roaming technology has advanced quickly. It combines 3DMAX software with interactive roaming technology to create architectural landscape design items including buildings, plants, and water bodies that exhibit excellent creativity[28]. 3DMAX modelling software has the characteristics of realism and high precision, and is compatible with a variety of post-rendering and roaming plug-ins, but the software can only display static 3D images and cannot achieve post-roaming [25]. As a result, a way for designing an interactive architectural garden landscape that roams is proposed, using Java3D and 3DMAX to achieve interactive roaming of an architectural garden landscape.

2 ARCHITECTURAL LANDSCAPE ROAMING DESIGN

Three platforms—3DMAX, Photoshop, and Java3D—are mostly used to realise the interactive architectural landscape wandering design based on 3DMAX [16]. The structure diagram of the architectural landscape roaming design is shown in Figure 1.

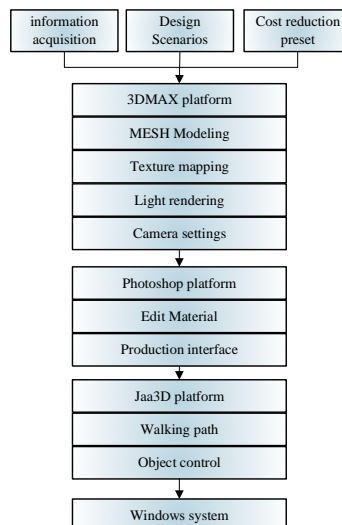


Figure 1: Structure of the architecturalgarden landscape roaming design.

2.1 3DMAX Visual Modelling

In the architectural landscape roaming design, the 3DMAX platform was chosen to be used for 3D visual modelling. To enhance the realism of the architectural landscape, the VRAY renderer was used as a rendering plug-in for the 3DMAX platform to enhance the capabilities of the 3DMAX software in the rendering of environmental spaces through material mapping and lighting settings in the VRAY renderer.

3DMAX provides a variety of modelling methods such as basic modelling and piecewise modelling, which can be used to create the required model through commands such as chamfering, cutting and joining [18]. In the modelling process, individual architectural landscape models are first created and then integrated according to the master planning plan to realize the modelling of the overall scene.

Prior to modelling using 3DMAX, the AutoCAD software is required to create the plan, elevation and section details of the architectural landscape garden project [14]. The overall plan drawn in AutoCAD allows the overall spatial location and the connection between the buildings and the landscape to be determined.

The final CAD plan is imported into the 3DMAX platform to create the scene model [7]. To avoid errors during the import process, we can save the CAD floor plan as a block to reduce unnecessary scene data and effectively reduce the file size.

After importing the CAD plan, the pavilion is modelled as an example. Firstly the height of the pavilion platform needs to be determined, as well as the angle and distance between the canopy and the apex of the pavilion platform. Shaped models such as the balustrade in the pavilion platform can be traced and edited using the Spline command in the 3DMAX platform to determine the final pattern. The drawn 2D spline is then converted to a 3D three-dimensional model using the Extrude command and the final 3D pavilion model with fancy balustrades is created using the Poly edit command [21]. With these steps, a complete base model of the pavilion can be completed and material rendered using the VRAY renderer.

Similarly, the landscape plants, stonework, rockery and rockery in the garden, as well as the services in the garden, can all be modelled using the above steps. As this design requires interactive roaming at a later stage, the position and accuracy of the various elements need to be considered during the modelling process, and they need to be constantly matched and aligned, especially between the foreground, middle and rear views.

Light is an essential element in landscaping and combining multiple light sources not only creates ambient light in the landscape, but also renders the landscape environment [23]. The VRAY renderer is used to render the landscape lighting, setting the lighting and projection according to different rendering needs. When rendering the model created, a main light source is needed, an auxiliary light source to complement the scene and a base light to adjust the light and dark effects of the objects in the model [5]. After completing the 3DMAX modelling, the Photoshop platform was used to texture the architectural landscape by editing the scene materials and creating the interface, and then the interactive architectural landscape roaming algorithm was used to achieve interactive roaming by setting behavioral scripts and paths using the Java3D platform [24].

2.2 Interactive Architectural Garden Landscape Roaming

The interactive roaming mainly uses the user's perspective to transform the scene in three dimensions, by clicking the mouse and keyboard to use the perspective transformation to obtain different visual sensations to achieve interactive roaming [1].

In the Java3D platform, the x-axis and y-axis are oriented horizontally to the right and vertically upwards, respectively, and the z-axis is the user's observation direction. When implementing interactive roaming in the Java3D platform, the position of each element in the garden scene is fixed relative to the coordinates, and the user converts the observation mode [20].

Figure 2 displays the placement of the perspective coordinates in the interactive roaming technique.

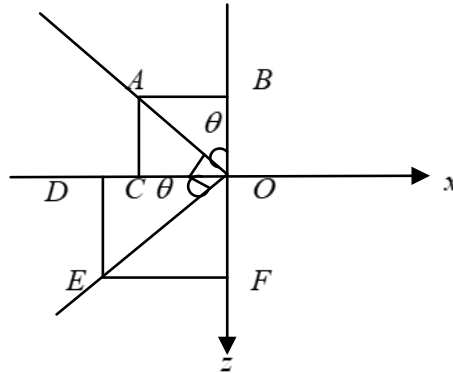


Figure 2: Coordinate positions of viewpoints.

Figure 2 shows that the angle between the line of sight and the negative direction of the z-axis is within 90° . When the observation line of sight moves from point O to point A , the observation line of sight needs to move from point O to point C in the negative direction of the x-axis and then to point A in the negative direction of the z-axis, and the moving process satisfies $|OB| = |OA| \cos \theta$, $|OC| = |OA| \sin \theta$. Let the observation of the original line of sight be (x_1, z_1) , and the number of steps forward to the new coordinate (x_2, z_2) be s . The following formula can be obtained:

$$\begin{cases} x_2 = x_1 - s \sin \theta \\ z_2 = z_1 - s \cos \theta \end{cases} \quad (1)$$

Observe that the line of sight starts at point O and moves to point E . Since $OE \perp OA$, we can obtain $\angle EOD = \theta$, i.e:

$$\begin{cases} |OD| = |OE| \cos \theta \\ |OF| = |OE| \sin \theta \end{cases} \quad (2)$$

Let the observation of the original line of sight be (x_1, z_1) and the number of steps to the left of the new coordinate (x_2, z_2) be s . The following formula can be obtained:

$$\begin{cases} x_2 = x_1 - s \sin \theta \\ z_2 = z_1 + s \cos \theta \end{cases} \quad (3)$$

Similarly, when θ is present in the other three quadrants, equation (1) can be obtained by setting the original line of sight to (x_1, z_1) and the number of steps forward to the new coordinate (x_2, z_2) to s .

When θ is present in the other three quadrants, equation (3) can be obtained by setting the original line of sight to (x_1, z_1) and the number of steps to the left of the new coordinate (x_2, z_2) to s .

Let the observation of the original line of sight be (x_1, z_1) , and the number of steps it moves backwards to the new coordinate (x_2, z_2) be s . The following formula can be obtained:

$$\begin{cases} x_2 = x_1 + s \sin \theta \\ z_2 = z_1 + s \cos \theta \end{cases} \quad (4)$$

Let the observation of the original line of sight be (x_1, z_1) , and the number of steps to the right to the new coordinate (x_2, z_2) be s . The following formula can be obtained:

$$\begin{cases} x_2 = x_1 + s \sin \theta \\ z_2 = z_1 - s \cos \theta \end{cases} \quad (5)$$

The above formula shows that the viewpoint coordinates change with the observer's line of sight, and the direction of change as well as the distance is the same as the direction of movement as well as the distance achieved [13].

Combining the above viewpoint transformation formula with Java3D technology, the algorithm for obtaining an interactive architectural garden landscape roaming is as follows:

```

Proprietary transform group goal TG;
/* mark a transform group object */
Proprietary level angle=0.0;
/* mark the horizontal view angle*/
Proprietary coordinate[]observer={_, _, _}
/* Mark the coordinates of the observation line of sight*/
Proprietary coordinate [] point = ·{_, _, _}
/* mark the coordinates of the target point*/
Establishment 3D=new Establishment3D ()
/*New 3D target*/
If (page front key) {
/*Setting the observation line of sight and the coordinates of the observation target according to
equation (1) */
Observer[0]=obtain cos (angle) ;
Observer[2]=obtain sin (angle) ;
Point[0]=obtain cos (angle) ;
Point[2]=obtain sin (angle) ;
T. view (new point 3D (observer) , new point 3D (point) , new
vector 3D ({0, 1, 0}) ) ;
The goal TG. put in transform (t) ; }
If (page left key) {
/* Set the observation line of sight and the coordinates of the observation target according to
equation (3) */}

```

```
If (page back key) {
```

```
/* Set the viewing line and the coordinates of the viewing target according to equation (4) */}
```

```
If (page right key){
```

```
/* set the view line and target coordinates according to equation (5) */}
```

The above algorithm is used to set up behavioral scripts and paths in the Java3D platform to achieve an interactive architectural landscape roam.

2.3 Virtual Scene Creation in Architectural Space

2.3.1 The First Creation of a Virtual Architectural Scene

The establishment of creating a space virtual scene mostly entails the following processes, using the VRML language as a tool for model development:

1. Scale and spatial coordinate construction

The bricks for establishing the building space are rendered at the same time as the building space is rendered to achieve the rendering, and the bricks are used to establish the scale of the building space constructed. The external walls of the building space to be established are covered with bricks of the same specifications, and the length and width of the independent bricks are used as the base unit of the building space[2]. (See Figure 3)

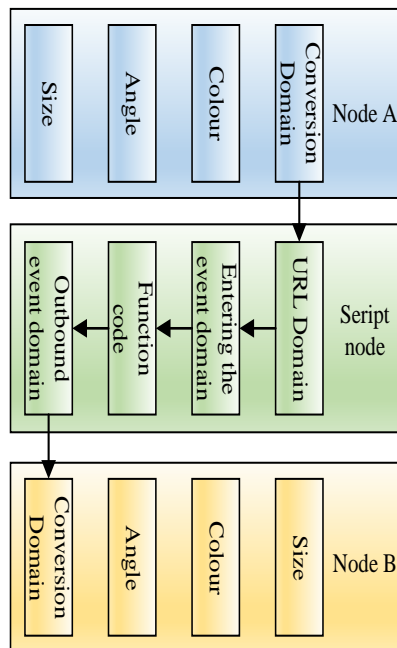


Figure 3: Script node design animation structure.

2. Component representation

The component positions are the specific coordinates of the building components in the building space right-angle coordinate system, and the x, y, z axis priority order can be used to determine the minimum coordinate points of the building components, or the positions built in the building space [15]. Following the physical establishment of each component in the building space, the building space data model is created by summing the physical models of all the components in the building space.

$$Building = \sum Structural(x, y, z) \quad (6)$$

3. Development of buildings' interiors

The steps in the building space are modelled with the following formula using them as an example to examine the building space entity modelling procedure:

$$Steps(a, b, c, d, h) \quad (7)$$

In this equation, a and b stand for the coordinates of the step's position and length, respectively; c and d stand for the step's width and height, respectively; and h stands for the total number of steps in the building space.

By following the methods above, you may create a rough model of the architectural space with contour features. Based on this, you can use texture mapping and other techniques to give the virtual scene's texture, colour, environment, and other visual effects a sense of reality[29].

2.3.2 Texture Mapping

The coplanar merging algorithm with Dihedral angle threshold is selected to search the building space scene hyperplane with contour characteristics, and the obtained hyperplane texture is used to replace the 3D model texture. The scene hyperplane texture acquisition is an important step of texture mapping. When decomposing the surface of the building space model into multiple hyperplanes, RTT technology is selected to vertically align the camera with the hyperplane and redraw the 3D scene. The current hyperplane texture is obtained through the above steps and rendered to the frame cache. The obtained different hyperplane textures are combined and output to obtain all the textures of the building space model. To achieve the texture stitching process, use the best insertion algorithm for the lowest horizontal line:

A two-dimensional combinatorial optimisation layout problem with polynomial uncertainty is texture mosaicing. Sort the various hyperplane textures in descending order in accordance with the "large area priority" approach. The method for arranging the texture is as follows:

$$G_n = \{G_1, G_2, G_3 \dots | (Z_{G_1} > Z_{G_2} > Z_{G_3} > \dots)\} \quad (8)$$

Where: Z denotes texture; G denotes superficial texture. It can be seen by equation (3) that the texture's largest superfacets are processed first.

When aligning the textures, choose the lowest horizontal line so that the bottom border of the largest texture is the original lowest horizontal line. If the horizontal line is divided into several segments, use the algorithm below to choose the texture T_i that has the lowest horizontal line's width and length as close as possible.

$$KG_i - K \leq \min(K(G_n) - K) \quad (9)$$

K is the shortest length of a horizontal line.

The minimum horizontal line is increased to a texture above the horizontal line and the minimum horizontal line of the texture is updated if there is no texture below the minimum horizontal line. Continue until all surface textures can be incorporated into the model.

3 Method Testing

The Windows 10 operating system was selected as the test platform for this paper to verify the effectiveness of the 3DMAX-based interactive architectural landscape roaming design method. Taking a certain architectural landscape planning area in a city as an example, this method was used to implement the roaming design for the area.

The scene display interface is illustrated in Figure 4 when you press the "Enter Scene" button in the system's initial interface after the design technology.

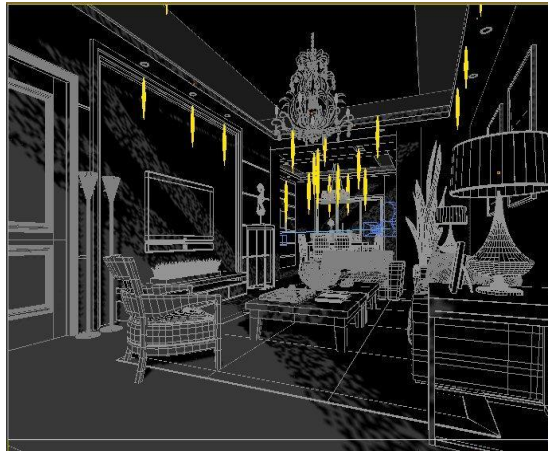


Figure 4: Scene display interface.

The initial position of the scene display interface is the starting position of the interactive roaming, and there are navigation buttons such as "operation description" and "back to the origin" in the scene display interface.

The system interface is shown in Figure 5 after clicking on the navigation button "Operation description".



Figure 5: Diagram of the operating instructions interface.

The interface diagram shows the operation keys for the forward and backward functions of the roaming scene, and the function operation keys can be modified by clicking the keyboard button in the display interface with the left mouse button, providing convenience for the user.

After clicking on the "Auto Mode" navigation button, the system automatically implements the scene roaming according to the path set by the method in this paper. (See Figure 6)

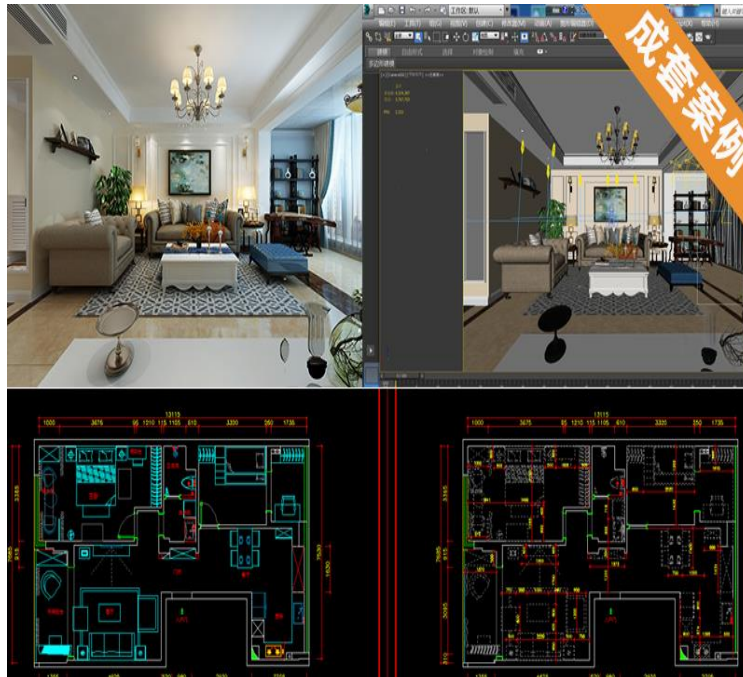


Figure 6: Screenshot of automatic mode scene.

"The "Auto Mode" automatically roams according to the set route, and the path cannot be changed by the keyboard in the middle of the tour. The "Auto Mode" roaming demonstrates the overall scene of the planning area, allowing the user to observe the overall landscape of the scene more intuitively and clearly [26].

The user can interact with the architectural landscape scenes through the "Autonomous Mode". After clicking on the "Autonomous Mode" navigation button, the user can control the roaming direction in the roaming scenes according to their own will by operating the buttons to achieve interactive roaming of the landscape. In the process of roaming in "autonomous mode", when there is an object below the viewpoint, the default is to cross over the object; when there is an object above the viewpoint [8],[9],[27], the system stops moving forward and the user changes the path around the object through operation, giving the user a realistic feeling as if they were in the scene [12]. Figure 7 illustrates the "Autonomous Mode" perspective.

The interactive architectural landscape roaming design technique of this method is demonstrated in detail through tests in the Windows 10 operating system, reflecting the good operational performance of this method and the realistic roaming effect. Theoretical knowledge is combined with practical operation to realize the interactive architectural landscape roaming design of this method.



Figure 7: View of autonomous mode.

This method is contrasted with the relative coordinate method and the interactive genetic method in order to better evaluate the interactive roaming performance of this approach [10]. Following the creation of 10 planning areas using the three ways, one hundred architectural and landscape architects were chosen and asked to judge the "goodness", "operational sensitivity", and "roaming effect" of the three methods. The outcomes are displayed in Table 1.

<i>Scoring indicators</i>	<i>Method of this article</i>	<i>Relative coordinate method</i>	<i>Interactive Genetic Method</i>
<i>Favorability</i>	<i>95.86</i>	<i>88.47</i>	<i>85.47</i>
<i>Operating sensitivity</i>	<i>94.87</i>	<i>89.18</i>	<i>84.17</i>
<i>Convenience of operation</i>	<i>96.19</i>	<i>87.47</i>	<i>86.30</i>
<i>Roaming effect</i>	<i>97.39</i>	<i>88.47</i>	<i>87.19</i>
<i>Interactive effects</i>	<i>96.29</i>	<i>90.48</i>	<i>83.70</i>
<i>Mean value</i>	<i>96.12</i>	<i>88.84</i>	<i>85.37</i>

Table 1: Comparing the results of the three methods.

The mean score of 96.12 for each of the 100 architectural landscape architects evaluating this method to complete the landscape roaming is higher than that of 7.28 and 10.75 using the relative

coordinate method and the interactive genetic method respectively, indicating that this method not only has better roaming performance and interactive experience, but also has higher user acceptance and can be applied to the actual architectural landscape roaming [11].

This system compares with the multi-star constraint system and the mixed reality system to determine the average response time of 10 different types of 3D building space virtual scenes when performing various operations like moving, zooming in, and going backward. The comparison results are shown in Table 2.

Scene Name	This article system		Multi star constraint system		Hybrid reality system	
	Scene construction	Texture Map	Scene construction	Texture Map	Scene construction	Texture Map
bedroom living Room	58	65	255	286	236	386
Room	62	69	216	275	306	346
Toilet	49	76	269	297	326	288
Restaurant	69	74	276	218	343	265
Study	68	87	287	237	287	286
Bathing center	70	85	242	286	270	346
Reading Room	73	77	239	268	365	376
Landscape Architecture	74	83	269	249	359	299
Exhibition Hall	77	55	298	259	375	265
Cafe	85	74	255	265	353	286

Table 2: Response times of several systems compared (ms).

The average response time of various operations performed during scene building and texture mapping in this paper is less than 90 ms, as shown in Table 2. The average response time of various operations performed during scene building and texture mapping with multi-star constraint system and mixed reality system is between 200 and 400 ms, which is significantly better than the other two systems, effectively proving that this paper has a high degree of performance. The average reaction time is between 200 and 400 ms, further validating the interactive performance of the system.

To further verify the interactive performance of the system, 100 architects were selected to evaluate the user experience of the 10 3D architectural virtual scenes built by the system using the expert evaluation method, and the multi-star constraint system and the mixed reality system were selected as the comparison systems, and the user experience comparison results are shown in Table 3.

Scene Name	This article system			Multi star constraint system			Hybrid reality system		
	Interactivity	Authenticity	Hierarchy	Interactivity	Authenticity	Hierarchy	Interactivity	Authenticity	Hierarchy
Bedroom	91.8	92.7	91.6	84.6	85.5	84.2	80.6	79.6	81.6

<i>Living room</i>	92.6	92.5	91.7	86.6	85.4	82.6	81.6	78.5	82.5
<i>Toilet</i>	92.5	95.8	91.5	85.5	85.8	79.6	82.7	76.6	83.7
<i>Restaurant</i>	92.7	93.8	92.6	87.2	86.2	78.6	83.5	81.5	84.6
<i>Study</i>	94.6	93.2	93.6	86.3	87.5	83.5	86.3	83.6	85.7
<i>Bathing center</i>	93.4	95.4	94.9	84.7	85.4	81.6	82.7	86.5	81.5
<i>Reading Room</i>	94.9	85.7	94.7	87.5	81.3	84.7	79.5	82.4	79.6
<i>Landscape Architecture</i>	96.6	96.6	94.3	88.7	85.4	86.4	79.7	83.5	78.6
<i>Exhibition Hall</i>	94.2	94.3	96.8	88.5	86.5	81.6	84.6	81.7	79.6
<i>Cafe</i>	96.7	91.8	91.6	83.7	82.4	76.6	81.7	83.5	81.6
<i>Average</i>	94.0	94.2	93.3	86.3	85.1	81.9	82.3	81.7	81.9

Table 3: User experience results for different systems scores.

The average scores of interactivity, realism, and hierarchy of 10 different types of 3D building space virtual scenes established by the system of this paper are 94.0, 94.2, and 93.3 respectively; the average scores of these three variables established by the multi-star constraint system are 86.3, 85.1, and 81.9 respectively. These results are shown in Table 3. The mean scores of interactivity, realism and hierarchy of 10 different types of 3D architectural space virtual scenes created by the mixed reality system were 82.3, 81.7 and 81.9, respectively [22]. The experimental results show that users have a good experience in establishing 3D architectural space virtual scenes by using this system, which again validates the interactive performance of this system.

3 CONCLUSION

3D MAX is widely used in architectural landscape design because of its powerful modelling capability. In order to present an interactive architectural landscape roaming design approach based on 3D MAX and evaluate the method using the Windows 10 operating system, this study combines the three platforms of 3D MAX, Photoshop, and Java3D. The test results show that the interface of this method is clear, the roaming scenes are realistic and the scenes can be interacted with through keyboard operation. One hundred architectural landscape designers were selected to design 10 architectural landscape planning areas using this method. The designers' evaluation of the design effect of this method shows that this method has the advantages of sensitive and convenient operation and good interactivity and roaming, and can achieve interactive roaming of architectural landscape. 3ds Max for architectural design and integrating it with virtual reality (VR) offers a powerful combination for immersive and interactive experiences. By creating detailed 3D models in 3ds Max and exporting them to VR platforms, architects and designers can take advantage of real-time rendering, interactivity, and collaborative capabilities. Incorporating VR into the design process allows for more intuitive exploration of architectural landscapes and enhances the presentation and communication of design concepts. However, it's important to stay updated on the latest advancements in both 3ds Max and VR development tools to make the most of evolving technologies in the field.

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