AKADÉMIAI KIADÓ

Pollack Periodica • An International Journal for Engineering and Information Sciences

17 (2022) 2, 168–174

DOI:
10.1556/606.2022.00321

ORIGINAL RESEARCH PAPER

Application of visual simulation in the activation of historical district

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Received: May 3, 2021 • Revised manuscript received: November 6, 2021 • Accepted: February 8, 2022
Published online: May 4, 2022

ABSTRACT

With the rapid development of China's urbanization, a large number of people have moved from rural to urban areas. People have proposed higher and more urgent needs for the urban environment. Particularly, the urban street landscape is close to people's lives, and the upgrading of design methods can improve the quality of life. Besides, the application of artificial intelligence design has become possible as information technology develops. In this paper, a visual simulator is established through algorithm models and applied to street landscape design.

KEYWORDS

artificial intelligence technology, street design, visual simulation, historical district

1. INTRODUCTION

1.1. Project background

Urbanization is developing rapidly worldwide, especially in China. According to the data of the United Nations in 2018, the global urban population accounts for 55.3% of the world's population, there will be 60.4% of the urban population in 2030 and 68.4% in 2050. Now, the urban rate in China has reached 59.2%, and the urban population is expected to grow by 255 million people from 2108 to 2050 [1]. A large number of people have put forward more urgent needs for urban architecture with the development of urbanization. In the process of urbanization, many historical districts have been forgotten. This situation has become an important factor affecting urban development. Recently, urban construction has shifted from pursuing quantity to pursuing quality and innovation. Innovative technology may be the key to sustainable urban development.

1.2. AI technology in urban design

Using Artificial Intelligence (AI) technology to solve the complex problems of historical blocks can give full play to the advantages of machine learning. Computer would be able to obtain the state transition law from the final state to the initial state through training and construct the corresponding algorithm model. The main content of AI urban design is to construct a behavior predictor that guides urban design by combining pedestrian behavior data and algorithm models. Pedestrian agent model is mainly used in urban planning, evacuation research, and building evaluation [2, 3]. In 2004, Kitazawa and Batty [4] applied the agent model to the field of micro-behavior simulation. The agent model adopted the shortest-path model as one of the evaluation criteria of genetic algorithms and applied the

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agent model to simulate the behavior of consumers. Sehnaz Cenani [5] conducted an experiment involving the basic concepts and rules of a shopping mall simulation model, emphasizing the significance of building a memory system and simulation learning ability during simulation.

1.3. Problem statement and design planning

First, the agent model mentioned above cannot compare the simulation results with the real data of pedestrian movement. Second, traditional pedestrian behavior simulation ignores the external environment's impact on peoples' vision and psychology, causing the accuracy of prediction to be not enough. Therefore, it is necessary to build an algorithm focusing on people's perception to dynamically reflect the internal state of pedestrians by collecting visual information. The cases of research can illustrate the relationship between perception, visual simulation and pedestrian behavior simulation.

2. DESIGN METHODOLOGIES

2.1. Site analysis

Minzhu Road historical district activation project is located in Zhanjiang City, China. This historical district is mainly composed of four streets, with an area of about 1 square kilometer. It is located in the old town, with outdated infrastructure and inconvenient transportation. This area is about 2 km away from Lingnan Normal University where young peoples are concentrated, and about 4 km away from the new town where a large number of residents gather (Fig. 1).

Fig. 1. Minzhu Road historical district
(*Source*: designed and drawn by Liang Zixin)

2.2. Survey of historical buildings

According to the characteristics, structure, history and current situation of buildings, these historical buildings are divided into three categories: preservation, renovation or demolition of the buildings [6]. There are more than 100 buildings, with shops on ground floors and residential areas on the upper floors. Their characteristic is that the corridor part facing the street is an extending to the store. In China, this arcade-style building is called "Qi-lou". As Zhanjiang has a subtropical climate, it is hot and rainy all year round. People walking in the corridor can avoid wind, rain, and sun. These buildings were established in the 1820s, when Zhanjiang was occupied by France. Under the influence of French colonial culture, these buildings presented a combination of French style and local style. At the end of the 20th century, Qi-lou buildings could not meet people's daily needs, they were abandoned quickly, and the preservation of these buildings was terrible. These buildings were used as electrical stores, furniture stores, breakfast stores, variety stores and antique stores, which is undoubtedly a kind of waste of historical buildings (Fig. 2). Moreover, the shopkeepers partitioned the interconnected corridor areas and occupied the public area of the corridor as a private store area. This situation damaged the structural characteristics of historical buildings. Some old buildings have collapsed, and their owners have built new buildings on the ruins. This kind of architectural form that conflicts with the overall landscape of the historical district is also a negative impact on the environment.

2.3. Design strategy

Minzhu Road historical district needs to develop a suitable business combination to attract more people and maintain the vitality of the area. While maintaining the characteristics of the historic district, it is better integrated into people's daily life.

Zhanjiang had a population of 7.73 million in 2019, and it is an important education city in Guangdong Province, with four universities. The number of universities in Zhanjiang is only less than that of Guangzhou. Zhanjiang has a good population advantage and good educational resources, gathering a large number of young and middle-aged populations.

Fig. 2. Qi-lou building status
(*Source*: photographed by Liang Zixin)

However, Zhanjiang is a coastal city, and citizens often choose to settle in coastal new town to pursue a high-quality life. The population density and the consumption level around the old town where Minzhu Road is located is very low. How to attract people and youth groups becomes a major challenge in renovation project. Because Zhanjiang is an important art education city, with the largest number of students receiving art education in Guangdong Province each year. Although there are many art training institutions in Zhanjiang, they are distributed in various places of the city in a scattered state. Minzhu Road can use art education and cultural industries to promote the development of historical district renovation projects, and plan more levels and richer commercial combinations in the area, this centripetal distribution can achieve more efficient resource sharing.

Furthermore, integrate the use of visual simulation into the historical block activation strategy and use AI technology to provide more effective design suggestions. This project related to the commercial pedestrian street, in the process of conducting visual simulations and pedestrian behavior simulations, the most imperative content is how to use agents to truly reflect reality. Generally, the agent has a purposeful activity in the commercial area. However, some users may not have a destination, and their destination in the shopping area may change rapidly depending on the environment or attractions. In this case, the most important operation of the agent is to select the appropriate store in its vision, suggesting that their behaviors are affected by visual factors [5]. Vision occupy an important position in pedestrian dynamic simulation research, so this research mainly focus on how to use agent to accurately reflect pedestrian dynamics under the influence of visual elements, and use the visual simulation model as an analysis tool in the renovation project.

3. MODEL DESIGN AND APPLICATION

Now, AI technology cannot generate a renovation design project, but visual simulation can be used as a basic AI technology to conduct design analysis, which is of great significance for guiding the development of design projects and making accurate design decisions. Visual simulation model can reflect the visibility and commercial value of each store, and different types of stores can be arranged according to the evaluation values of different areas to achieve effective allocation of resources.

3.1. 3D model construction

In the field of digital media, Chen Jianhui [7] has conducted several studies on agent-based interfaces. His research indicated that future researches may incorporate 3D space to examine the impact on visible areas of attention. The establishment of a 3D model that truly reflects the situation of the project, and the classification of visual elements on this basis, is one of the requirements for using agent to simulate the reality [8]. Stores can use visual elements to influence whether pedestrians enter the store. These factors have both positive and negative effects. For example, visual elements like billboards, posters, windows, and entrances showing the characteristics of the stores would attract peoples. However, corridor columns, street lights, trees, and devices would hinder people's activities and reduce the attractiveness of shops. In addition, the models of streets, buildings, and other objects are simplified. For example, in terms of buildings, mainly structural features are retained in the modeling, and most of decorative details are omitted, so as to ensure the running speed of the simulation model. As mentioned earlier, some shopkeepers partitioned the corridors and occupied these public areas as private store. Because this behavior severely damaged the structural characteristics of Qi-lou buildings, the original structure of the building should be restored in future designs and the connectivity of the corridors should be rebuilt (Fig. 3).

3.2. Visual simulation model construction

In the 3D model, some Observation Points (OP) are set up according to people's activity routes to realize the visualization and quantification of the influence of the store view objects. The area is divided using a grid composed of squares with a width of 1 m. The agent walks on the grid, and the points on the grid are used to record the agent's walking route. The agent's activities are simplified from 360° to 8 directions: east, south, west, and north, southeast, northeast, southwest, and northwest (Fig. 4). According to the path, a camera with a lens length of 28 mm in Rhino is placed on each OP with a height of 1.5 m. Then, the eye height of the observer can be simulated, and the state of the observer

Fig. 3. Restore the corridor of Qi-lou building
(*Source*: photographed and drawn by Liang Zixin)

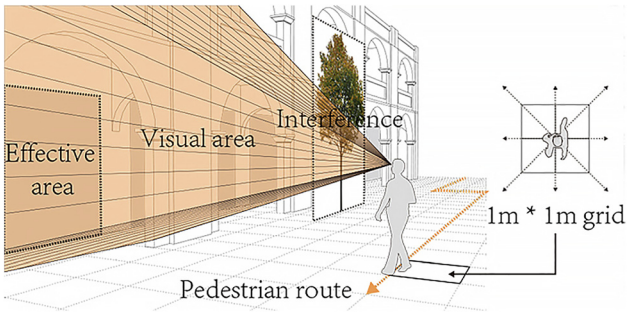

Fig. 4. Visual simulation
(*Source*: designed and drawn by Liang Zixin)

viewing the building horizontally and collecting images is represented. Besides, the field of view and the focal length are set to 75° and 20 m, respectively. Afterward, 108 rays are emitted from camera and use Grasshopper platform to calculate the number of rays projected on the target. The score of Evaluation Visibility (EV) is defined as the ratio of the number of rays hitting the view objects [9]. The Evaluation Visibility Ratio (EVR) is the ratio of the visible area inside the building to the area of the façade (Table 1). Moreover, the greater the EVR score, the higher the visibility inside the store, and the greater the attraction of the store to pedestrians. The smaller the EVR score, the higher the privacy of the interior space of the store (Fig. 5).

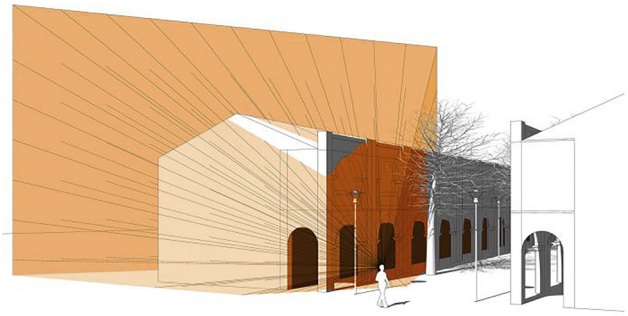

Fig. 5. Visual simulation
(*Source*: designed and drawn by Liang Zixin)

3.3. Visibility evaluation analysis

The visualized area ratio of the store can be exhibited through the visual simulation model. These figures illustrate the undisturbed EVR and the EVR affected by trees and street lights when the store does not hang advertisements (ads) on the façade of the building. In the first case, the visibility of the internal space of the store changes less frequently, and the visible time of the internal space is continuous (Fig. 6). In the second case, people's attention to the shop fluctuates significantly due to the disturbance. Because of the lack of coherent attention, such shops are easily overlooked (Fig. 7).

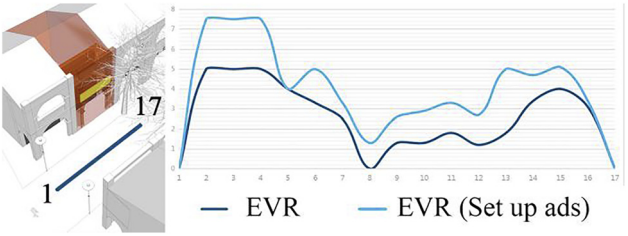

Fig. 6. EVR for setting up ads without interference
(*Source*: designed and drawn by Liang Zixin)

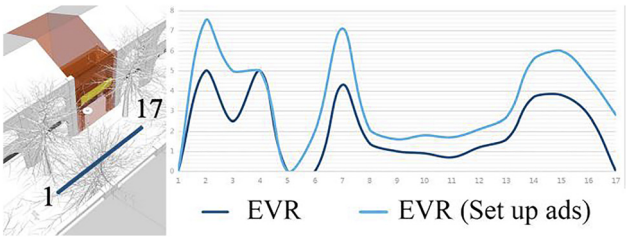

Fig. 7. EVR for setting up ads under the influence
(*Source*: designed and drawn by Liang Zixin)

3.4. Site plan

The EVR is calculated by the visual simulation model can evaluate the visibility of different stores, including the visibility of interior and external publicity of the store. Through the evaluation, the store can be divided into three categories according to the visibility score: continuous visual elements, affected visual elements and trivial visual elements (Fig. 8). In the picture, Consumers in these stores are mostly random people with no clear purpose. So, these stores need to attract more customers through exposure, so they have higher requirements for external visibility of the internal space.

Table 1. Model design and value input (*Source*: drawn by Liang Zixin)

Pedestrian Route selection (PR)			
PR^1	Route anchor	A square grid with a width of 1 m divides the area	
PR^2	Route direction	Simplify 360° into 8 directions	
Observation point selection			
OP^1	Number of observation points	Number of grid points on the route	17
OP^2	Observer height	*Z* coordinate direction of observation point	1.6 m
Observer parameters			
OP^1	Camera position	Observer position	1–17
OP^2	Lens length of camera		28 mm
OP^3	Viewing angle of camera		75°
OP^4	Focal length of camera		20 m
Visual Simulation (VS)			
VS^1	Number of ray for simulation	Rays projected on the object	108
VS^2	Visual Object Score (VOS)	Rays projected on the visual object	
VS^3	Building Score (BS)	Rays projected on the building	
VS^4	Object visibility ratio	EVR = VOS/BC·10	

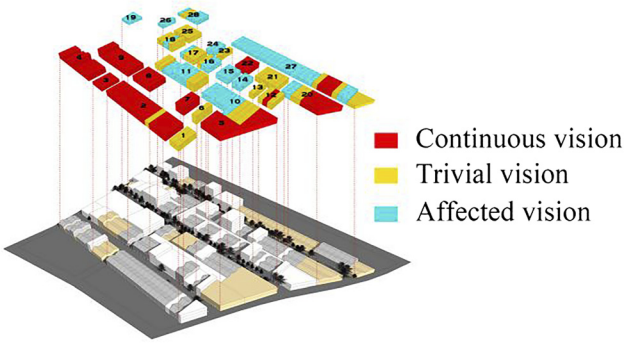

Fig. 8. Visibility evaluation of historical buildings (*Source*: designed and drawn by Liang Zixin)

Secondly, the buildings' visual elements are affected; they are set as art materials stores, stationery stores, and antique stores. Consumers in such stores basically have a clear shopping purpose. For example, customers who go to art material stores and stationery stores are generally students from surrounding art training institutions. Because of the shortage of these materials, they will go to the store to purchase, so they are purposeful, and they will actively look for these stores. This kind of store can be planned in areas where the visibility is disturbed by some influencing factors, and even this arrangement will not have a major impact on the store's business. Finally, buildings with trivial visual elements are designed as art training institutions, Chinese medicine hospitals and kindergartens. These buildings do not have high requirements for the display of internal space and the high flow of people. Their user structure is relatively stable. On the contrary, they need a quiet, safe and private space.

3.5. Architecture renovation

In the renovation of historical buildings, the visual types of different buildings should correspond to the functional characteristics of the store. According to the buildings preservation, they are divided into three types: preservation, renovation, and demolition. If the building structure was too old to support subsequent renewal work and had potential safety hazards, these old buildings are demolished. Besides, the other buildings should be preserved, and their building structure should be restored.

This renovation project is mainly divided into three aspects:

3.5.1. Overall design. This renovation project should achieve a balance between the historicity of the old building and the functionality of the modern building. For general historical buildings, the most common protection method can be used to change the original use. This not only protects the buildings, but also gives them new life through industrial transformation. Most Qi-lou buildings will be used as stores in the future, and how to promote themselves will become the focus of businessmen. Therefore, it is necessary to consider how to set up ads in stores without destroying the appearance of historical buildings. Design team uses visual simulation models to analyze and evaluate different forms of advertisements. The number of rays projected on the facade of the building is called building score. Under the influence of obstructions, the number of rays projected on visual objects that can reflect store characteristics is called visual object score. EVR is a numerical value for evaluating the visibility of store promotion factors The following table can reflect the changes in EVR scores under different influencing factors with people's activities, and when the value is higher, the effective field of view area is also more obvious (Table 2). The EVR scores in different situations can be compared through visual simulation when ads are set up. This research shows that the proper placement of ads on the facades of historical buildings can effectively expand the scope of publicity of the store and extend the perception time of pedestrians. Compared with uncovered stores, those covered by trees and street lights have a more significant effect on brand promotion by setting up ads. The conclusion is that the reasonable display of ads without destroying the structural characteristics of Qi-lou buildings should be encouraged and supported (Fig. 9).

3.5.2. Detail design. The renovation project realizes the coexistence of order and variety. Most Qi-lou buildings follow the same order of height, width and building structure. Order means balance, symmetry, and repetition. Excessive emphasis on order will lead to monotony, giving people a sense of stiffness and boredom. Based on the original design rules of Qi-lou buildings, the decoration details, materials and colors of the buildings can be adjusted appropriately to make each building have its own

Table 2. EVR in different situations (*Source*: drawn by Liang Zixin)

EVR in different situations													
Moving distance (m)	0	1	2	3	4	5	. . .	11	12	13	14	15	16
EVR without interference													
Building score	4	4	4	4	5	6	. . .	52	62	62	45	32	18
Visual object score	0	2	2	2	2	2	. . .	6	11	21	18	10	0
EVR (=VOS/BC*10)	0	5	5	5	4	3.3	. . .	1.2	1.8	3.4	4	3.1	0
EVR for setting up ads without interference													
Building score	4	4	4	4	5	6	. . .	52	62	62	45	32	18
Visual object score	0	3	3	3	2	3	. . .	14	31	29	23	11	0
EVR	0	7.5	7.5	7.5	4	5	. . .	2.7	5	4.7	5.1	3.4	0

Fig. 9. Advertisement settings for store
(*Source*: designed and drawn by Liang Zixin)

Fig. 10. Order and diversity in Qi-lou buildings
(*Source*: designed and drawn by Liang Zixin)

characteristics (Fig. 10). The characteristics of the store are displayed through architectural features, not limited to the use of doors, windows and billboards, and the efficiency of external publicity is improved by enlarging the visual display area.

3.5.3. Spatial interaction. This project demonstrates the vitality of the street by realizing visual communication. The aesthetic reconstruction of historical Buildings should not simply pursue the appearance of buildings, but should try to express the activities of people living in them [10]. Modern highways and buildings have cut the connection between people, and people in modern society are more accustomed to hiding their lives. These behaviors weaken the vitality of the city. In the renovation project, a pedestrian street of moderate scale is used to create a space that encourages communication. The design considers how to realize the interaction between the internal space of the building and the external environment, so that the corridor originally used for sheltering from wind and rain will not become a barrier to people's communication in modern society. The perforated steel and polycarbonate materials can be used to renovate the damaged exterior wall of the building. The color of new material can be close to the original color of Qi-lou buildings, and it also has the characteristics of light weight and transparency. On the one hand, the texture of the new material is compared with the texture of the original material to produce unexpected artistic effects. On the other hand, pedestrians outside the building can feel the atmosphere of the interior space through the materials, but they cannot see the interior clearly, which ensures the privacy of the interior space; and the people inside can also see the passing by. This design allows people inside and outside the building to feel the connection between themselves and others, thereby showing the vitality of the street (Fig. 11).

Fig. 11. Renovation of Qi-lou buildings
(*Source*: designed and drawn by Liang Zixin)

4. CONCLUSIONS

Recently, AI has become more and more widely used in the field of architectural design, and the advantages of "AI design" are consistent with the law of urban development in China today. In the process of urbanization, many historical districts have been forgotten with the establishment of new urban areas. This situation has become an important factor affecting urban development. Innovative technology is the key to sustainable urban development. However, traditional pedestrian behavior simulation ignores the external environment's impact on pedestrians' vision and psychology, making the accuracy of prediction not enough. Thus, an algorithm focusing on people's perception is built in this paper, and the internal state of pedestrians is dynamically reflected by collecting visual information. The EVR can clearly and accurately reflect the visibility of each store. In other words, the commercial value of each area can be evaluated through the EVR value, and different types of stores can be arranged according to the EVR value of different areas to realize the effective allocation of resources. In future research, these data can be combined with a variety of complex factors to be used in pedestrian behavior simulators. These simulation models can provide guidance and advice for urban designs.

ACKNOWLEDGEMENTS

The preparation of this paper was supported by Marcel Breuer Doctoral School, University of Pécs. I do appreciate

for the PhD & DLA Symposium provides academic exchange opportunities for this research. I am grateful to Professor Géza Várady and Professor Márk Balázs Zagorácz for their support of this research.

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