ProcPlan: A Procedural Evaluation Strategy for Tourist Attractions Planning

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Abstract. Due to the relationship between design quality, tourist enjoyment, tourist satisfaction, tourist numbers, and tourist revenues, this paper intends to discover the influences which the tourist buildings' arrangement has on tourist behavior and enjoyment in a scenic spot, and present a procedural method to evaluate the tourist attractions' design quality in a quantified way. Through crowd simulation and several iterations, the evaluation system tries to lead the designers to a better configuration of the scenic buildings. The involved gamification stimulates the user to pursue a higher score. A case study illustrates the applicability and effectiveness of our strategy.

Keywords: Crowd simulation · Pedestrian tourist · Serious game · Agent-based model · Tourist satisfaction

1 Introduction

Tourism has become one of the biggest revenues for one district, and more places have inclined to explore the value of nature beauty. Evaluation for tourist attraction planning can help designers and administrators find a more efficient way to receive reputation, draw tourists' interests and gain profits. There exist many research works which assess a design scheme in the forms of theory or anaphase questionnaires. However, in this paper, we attempt to do the evaluation in a procedural way, which is through crowd simulation.

Crowd simulation plays an important role in adding realism to the virtual environment by bringing life to the virtual worlds, which makes it a popular issue in the production of entertainment content creation, security evaluation and urban planning. While most researches focusing on addressing problems in the simulation of emergency circumstances, such as battles or disaster scenes, this paper aims to apply crowd simulation to the evaluation of tourist attractions planning in a virtual tourism scenario, which is a typical non-emergency environment. We hope that the result of our research can be employed to provide spatial analysis of effects which tourist buildings have on tourists' impression, support planners, managers and administrators with their visually decision making processes and assist them in improving the spatial arrangement of public facilities to meet the tourists' needs. Gamification is also involved to stimulate the user to pursue a higher score, while obtaining a better arrangement of tourist buildings.

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The contributions of our work are as follows:

- Propose a procedural way, a crowd simulation method to evaluate the tourist attractions planning.
- Intend to provide an assist tool for the designers, managers and administers in their first planning stage, and help them with the improvement of their design schemes.
- Using an internal motivation mechanism–*gamification* to stimulate the user positively: a higher score corresponding to a better arrangement of the buildings and also a better design scheme.

The rest of our paper is organized as follows. Section 2 introduces some previous works relating to tourist attractions evaluation and crowd simulation. In Sect. 3, we outline the whole evaluation strategy. Section 4 presents a detailed illustration of the evaluation strategy, and in Sect. 5, a case study is performed to analyze the performance of our method. Conclusions and future works are discussed in the final section.

2 Related Work

There exist many research works on tourist sites evaluation, where most of them are based on consumer satisfaction. Consumer satisfaction is early proposed in paper [1, 2], and the definition of it has many various versions. Kozak [3] summarized four measurement approaches for consumer satisfaction: expectation-performance, importance-performance, disconfirmation and performance-only. Parasuraman et al. [4] proposed a famous measurement scale–SERVQUAL which is commonly used nowadays [5, 6]. Gronroos defined three dimensional facts to decide the tourist satisfaction [7]. Taylor proposed the SERVPERF [8] and made a comparison with SERVQUAL. NDSERQUL model proposed by Brown measured the disconfirmation between the pre-purchase expectations and the perceived performance after the purchase [9]. Hughes [10] believed the tourist satisfaction possess relativity, which meaned that the tourist can also be satisfied even though his or her expectation was not fulfilled. He also divided the tourist satisfaction into four levels: very satisfied, quite satisfied, satisfied and not very satisfied. Jonhyeong [11] developed a measurement scale to assist the understanding and effectiveness improving of memorable experience. For further information, please refer to paper [12].

While most works focus on exploring the relationship between tourist satisfaction, tourist expectation and tourist loyalty through questionnaires and website survey, we intend to use the performance-only approach, apply the tourist enjoyment as a replacement of the tourist satisfaction and employ a procedural way, which is crowd simulation, to evaluate the planning performance.

Researches of crowd simulation can be mainly divided into two categories: macroscopic methods and microscopic methods. The macroscopic methods [13, 14] concentrate upon the whole crowd's movement features while the microscopic methods mainly focus on the characteristics of individual behaviors involving both physiological and psychosocial factors [15]. Between them, the microscopic methods show great advantage in obtaining fine-grained results in the simulation of heterogeneous individuals, which makes them quite proper in most simulation applications. Among them,

agent-based method is a typical and also a popular approach in large scale crowd simulation and is also used in our method. To develop our pedestrian tourist simulation model we take inspiration from the hierarchical behavior model proposed by Reynolds [16] and ViCrowd model proposed by Musse et al. [17] to take a fully consideration of the complex factors of tourist crowds. Motion planning is not the key issue in this paper. Here we only focus on the description of our procedural evaluation, not on the navigation and motion planning of the crowd.

3 An Overview of Evaluation Design

Here we present a brief look and a prelude introduction of our evaluation strategy, including the evaluation criterion, scenario description and evaluation process.

3.1 Evaluative Criterion

Our evaluation strategy is based on an interesting finding between tourist revenues and tourist enjoyment (Fig. 1).

Fig. 1. Relationship circle of design quality, tourist enjoyment, tourist satisfaction, tourist numbers, and tourist revenues

There exists a meaningful positive relationship between the design quality, tourist enjoyment, tourist satisfaction, tourist numbers, and tourist revenues. Each promotes the following one: A good design quality increases the tourist enjoyment, the addition in enjoyment reflects the addition of tourist satisfaction, higher satisfaction attracts more people to come to this place, more tourists bring more profits and the gains in income help improve the design quality. Accordingly, we employ the tourist enjoyment as the quality evaluation criterion and help analyze the influence which scenic buildings' arrangement has on tourist enjoyment.

3.2 Scenario Description

According to our observation, the tourism scenarios share some similarities. First, the scenic environment contains limited paths for the tourists to walk. Besides, except for

those walking paths and the buildings for visiting, other places are forbidden to access especially in mountain areas, considering the tourists security. What's more, the movement of the tourists from one place to another happens along the walking paths.

Due to the traits above, we intend to use a two-dimensional raster image to describe the background of the environment and depict the walking path with waypoint graphs. By doing so, the environment can be easily constructed while maintaining the scene features. The background image can be a bird-eye view of the undeveloped attraction scene or a hand-drawn map of the scenic spot (shown in Fig. 2), and is mapped on a plane mesh. Besides, considering the map scale of the plane mesh to the real scene, we set the plane mesh as 100 units wide, and adjust the height according to the bird-eye view image.

Fig. 2. Scene representation (with waypoints)

3.3 Evaluation Process

The whole process of our evaluation is listed as follows (Fig. 3):

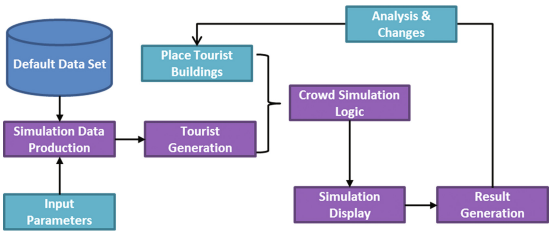


Fig. 3. Evaluation process (light blue ones represent for user's manipulations, purple ones for the program process) (Color figure online)

Firstly, the users need to input the parameters such as the tourist number, tourist speed, tour time limit and so on for simulation initialization (see in Table 1); then the program runs the crowd simulation process in a semi-automatic way, which means in this time, you can still change the tourist buildings' position; during the simulation, the tourist agents wander round the whole scene according to their own attributes and

preferences, and gain enjoyment values about the tourist scene; when the simulation is over, a detailed analysis table is given for the user. On the basis of the presented results, the user can make changes of the tourist building arrangement and do the simulation again to see the differences. In the following section, we will introduce the evaluation strategy we designed for the tourist scenario.

Table 1. Main parameters for initialization

Parameters	Description
Arrival speed	Arrival speed of the tourists
Population ratio	Distribution ratio of man, woman, old and young
Full limit	Time limit for tourists to stay in the scenic spot
Sense range	Radius of the perception area
Building cost	The cost of scenic building

4 Design for Evaluation Strategy

4.1 Modeling of Tourist Attributions and Behaviors

In our paper, the tourist is described with agent-based model method. We intend to map a real human being's attributes to our agent model. These attributes include physiological and sociological aspects, such as classifications of the population, conceptions on the environment, awareness about the neighborhood agents, communications with other agents, emotions, appreciation for the scenic buildings and so on. Inspired by the ViCrowd and the two-layered model in paper [15], we design our agent model to contain the external and internal information. The external information relates to the knowledge which the agent perceived from the outside environment including the awareness of the neighborhood scenic buildings and agents, the location of itself and so on. Other external information also contains the perception of the team (group with a tour guide) and team members. Internal information means the intrinsic features of the agent such as moving speed, emotions, preference of the particular buildings and so on. Figure 4 is an illustration of the two kinds in our agent model.

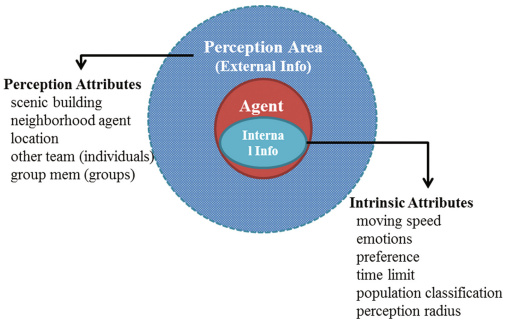


Fig. 4. External and internal attributes of the agent

While in the tourist scenarios, tourists tend to follow a nearly fixed and simple behavior pattern: keep proceeding along the path until encounter a tourist building; then deflect to appreciate the scenic buildings; after a period of viewing time, return back to the path and move forward again. The tourists' physical strength may decrease gradually by time. When their energy falls below a certain threshold, the tourists may become tired or exhausted. In this time, a resting spot can help the tourists recover energy. If the tourists lose interest for the rest scenery or feel too exhausted to move on or just exceed the time limit, they will tend to leave.

With social relationship such as kinship or leader-follower, individuals may travel in groups. Groups with kinship often consist of family members or friends while groups with leader-follower relate to tour teams with a tour guide. Different social relationship leads to different behavioral features. Take decision making for example, the groups with kinship such as family members or friends tend to balance their interests and find the proper way to go. Besides, one of the group members may play an essential role in the decision making process, which means his or her opinions weigh higher than others. In a leader-follower group (called "team" here), the leader makes the decision according to a pre-decided route and the followers simply follow the leader while keeping a distance.

4.2 Heuristic Procedural Modeling for Tourists' Enjoyment

Tourists are the ones who tend to enjoy the pleasure and to pursue larger pleasure unconsciously. This leads to the main theory basis of our evaluation strategy, which is pursuing pleasure is the intrinsic motivation of tourists. When wandering the scenic spot, tourists mainly appreciate the attractions to gain their enjoyment.

We define the tourist enjoyment as the pleasure tourists received from appreciating the scenic spot in limited time. It can be accumulated, for one feels more joyful in viewing two scenic buildings than viewing one. It can be related to viewing time, for one may receive much more pleasure from the very first beginning of appreciating the scenic building per minute than after a long staring at it. It can be affected by the tourist's current physical statement, for when the tourist is full of energy, he or she may involve a little bit more in enjoying the the scenic spot's beauty, and when the tourist is tired or even exhausted, he or she may eager to find a place for rest or just leave. It can also be affected by the total visiting time in the scenic spot. For when the visiting time exceeds a limitation, the tourist may give up the following viewing spots and choose the nearest exit to leave. Besides, the scenic spot may cause an overall impression to tourists and this impression may have slightly difference for different individuals. What's more, different people have their preferences for different scenic buildings, namely different types of buildings possess different attraction degrees to different people. Considering the age and gender, tourists can have four categories: man, woman, old and child, among which man and woman represent young, mid-young or mid-aged people with different gender; old and child represent the specific groups with two extreme ages.

So we summarize a generalized equation for tourist enjoyment as follows:

$$J_T = \sum_{i=1}^{n} J_{ibase} + \sum_{j=1}^{m_i} \sum_{i=1}^{n} w_{ij} * J_{ij} \tag{1}$$

Where, J_{ibase} is the basic impression agent_i has on the current whole tourist scenario, w_{ij} represents the influence weight of tourist building_j to agent_i, J_{ij} represents the perceived enjoyment of agent_i by viewing building_j, n is the number of tourists, and m_i is the number of tourist buildings agent_i has viewed.

We believe that the value w_{ij} is affected by the emotion of the tourist agent and also the viewed time of the agent. For when a tourist is in a bad mood, such as being tired or exhausted, he or she may less appreciate the scenic building, and a long-time wandering in the same site also brings less pleasure for the tourist. So the weight can be further written as:

$$w_{ij} = w_{emotion} + w_{viewedT} \tag{2}$$

As for the calculation of J_{ij}, it is based on the hypothesis that every building owns its own glamour, and this affection forces may be a bit higher for the tourists who especially fond of this building.

$$J_{ij} = p_{ij} * g_{jbase} \tag{3}$$

Where, g_{jbase} is for the basic glamour of building_j and p_{ij} is the preference of the tourist agent_i on building_j.

So, Eq. (1) can be:

$$J_T = \sum_{i=1}^{n} J_{ibase} + \sum_{j=1}^{m_i} \sum_{i=1}^{n} (w_{emotion} + w_{viewedT}) * p_{ij} * g_{ibase} \tag{4}$$

5 Case Study

5.1 Case Design and Specifications

We employ the evaluation method with a program in the form of the game developed with Unity 5.1. For more precise evaluation, we make some simplification and specifications in this case.

- As the value J_{ibase} blurs among different individuals and is hard to give the exact value. Here we just suppose that all the tourists have the same impression of the tourist site and remove it from the calculation equation.
- In this case, we set the viewed time of the tourist with a constant and regard the physical strength to be the biggest influence factor. According to the physical strength, the tourist emotions can be divided into normal, tired, exhausted, and depleted, using a piecewise function to calculate the $w_{emotion}$.

$$w_{emotion} = \begin{cases} 1 & 0.3 \le r \le 1.0 \\ r & 0.1 \le r \le 0.3 \\ 0 & 0 \le r \le 0.1 \end{cases} \quad (5)$$

Where, r is the ratio of current physical strength to the full physical strength of the tourist.

- All the buildings are divided into three levels: Level 1, Level 2 and Level 3. The buildings in the same level share the same glamour value which is specified through input.
- p_{ij} is an experimental value, in our case, it is 1.5 for favorable buildings and 1.0 for normal buildings.

Here, we classify the tourist buildings into five categories: scenic spots, shopping center, theatre, recreational facilities, and resting facilities which is correspondingly favored by man, woman, old, young and all.

5.2 Results and Analysis

We employ preset models to represent different kinds of tourist buildings (see in Fig. 5), and then design three arrangement plans (shown in Fig. 6) for comparison.

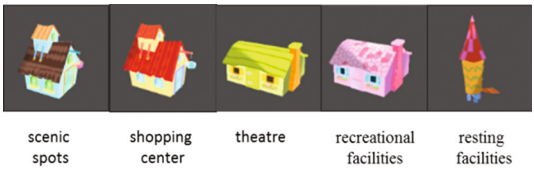
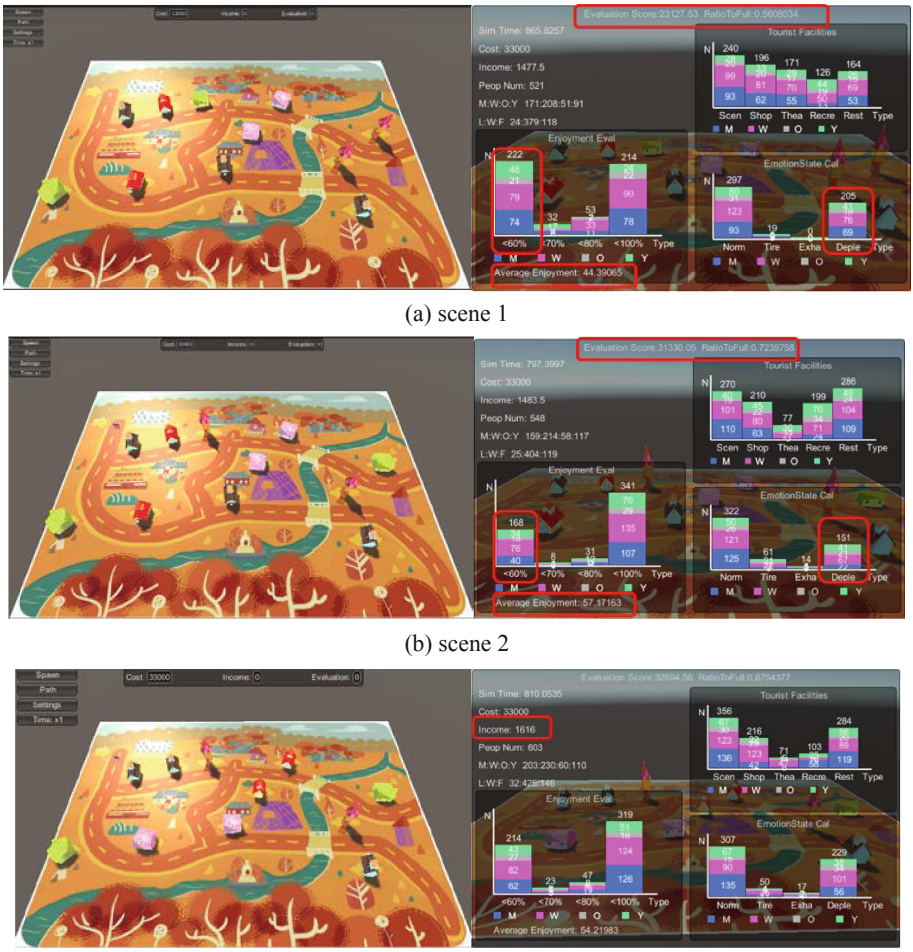


Fig. 5. Preset models for facilities

The results and tables shown above can reveal some interesting relationships between the tourist facilities' arrangement and the tourist enjoyment. The three scenes are same in facilities' numbers and kinds and also share the same initialized parameters sets. From Fig. 5(a), it can be figured out that the number of the ones whose satisfaction is below 60 % or being depleted when leaving the scenario is very high. In Fig. 5(b), the only change we've made is to move the resting facility to the middle of the scene, and we can see a clearly increase in the enjoyment value. This gives us the advice that putting the resting facilities in the middle and in the end of the tour journey can improve the tourists' enjoyment. As in Fig. 5(c), putting the facilities which favor by most of the tourists to the main road can greatly increase the incomes.

In our case study, we employ gamification, which is score-stimulation to arouse the tourists' aspiration in pursuing higher score, which is a positive promotion for the performance.



(a) scene 1

(b) scene 2

(c) scene 3

Fig. 6. Influences of different facilities arrangement on tourist satisfaction (Color figure online)

6 Conclusion and Future Work

This paper presents a procedural way for tourist scenario evaluation through crowd simulation iterations, which can be used to assist the designers for quick change and improvement with their design scheme. A case study illustrates the effectiveness and applicable of our strategy. The following research will focus on providing the user a more realistic crowd simulation performance and a more honest revivification of the scenic spots when keeping a high efficiency.

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