Simulation and research on some buildings in Ningbo

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Abstract. Simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

1. Introduction

Significance of Simulation:
(1) Understanding the behavior of the system and/or evaluating various strategies for the operation of the system. [Shannon 1975]
(2) Simulation is less costly than real life experimentation, by thoroughly testing changes with simulation ahead of implementation.
(3) Test different ideas under the same circumstance with the simulation software. The developers can test the same system repeatedly with different inputs, ensuring that any changes to processes have been thoroughly tested.
(4) Determine the long-term impact of process changes. Usually, the benefit of a simulation project comes from not only the end results of the project, but the exploration between the start of the project and the point of getting answers to make a decision.
(5) Determine the potential impact of random events. Only simulation is capable of incorporating the randomness that occurs in real-world systems, so the developers can see the consequences of events being delayed by resources not being available when they are needed. (Xie, 2015).
(6) Simulation guides thinking around processes. As there is no limit to the degree that the developers can try innovative ways to improve processes, the developers can quickly come up with many more ideas to test and measure as a result. (Abu-Taieh, 2007).

2. Technical basis

Anylogic:
Anylogic is a set of modeling and development tools combining with a variety of simulation (simulation) theories. (Biljana, 2018)

3. Simulations

3.1. Introduction to simulations
Three simulations are included: Ningbo Incity Mall, Ningbo Subway of train station, Ningbo Qian Hunan Road crossroads.
Ningbo Incity Mall: In the Incity simulation, developers built the first floor of Incity based on the plan design of Incity mall facilities (Fig 1). At the same time, the 3D version and the logic of customers were built based on the real situation and the data which is collected (Fig 2 and 3). User can simulate the daily work of the mall with the simulation. Using the change of parameters to simulate some extreme situations is also available in this case.

Ningbo Subway of train station: In the subway simulations, the developer simulates the railway platform including the running of the trains and the commute movement of costumers. The developer also builds the escalator which included the in and out probability based on the data collected (Fig 4). Similarly, there is the logic builded for the whole process (Fig 5 and Fig 6). In the subway simulation, the crowd density becomes obvious with the density map, and the users could get accurate value of exact point in the platform map.

Ningbo Qian Hunan Road crossroads: In the road crossroads simulation, the developer simulate the running of the cars in the crossroads (Fig 7), set the probability of passage according to the data collected. Building the logic of the trend of cars from each directions (Fig 9). 3D version is built at the same time (Fig 8).

3.2. Build process of simulations

3.2.1. Ningbo Incity Mall

The 2D animation:
Drawing the 2D version base on the plan design of mall. There are 4 entrances, 38 shops, 2 escalators and one lift in the first floor in total. Meanwhile, the maximum pedestrian volume roughly reaches 1200. The most popular shop is Xi Tea according to the pedestrian volume data, 200 people is reached in the shop at the same time.

![Figure 1. The 2D animation](image1)
![Figure 2. The 3D animation](image2)

The logic:
The pedestrian come from four entrance, shows as EntranceSource1, EntranceSource2, EntranceSource 3, and Entrance Source 4 in the logic view. After that, there is a "select Output" for pedestrian: go to the exit, go to the cost zone, and go to the specific cost zone.

Go to the cost zone: costumers may go to the zone which cost time. All of these zones already classify into different group. For instance: shops, toilets, lifts.

Go to the specific zone: costumers may go to the specific zone which costs more time than other zone. In this case, the developer divided them in specific zone, and also set the parameter to control these zones.
3.2.2. Ningbo Subway of train station

The planar animation:

Firstly, the planar animation drew base on the design of the Ningbo train station subway station. There are 2 train tracks, four up and down escalators and 48 train entrances totally. The developer added density map on the animation which demonstrates the pedestrian density during the simulation period.

The logic:

There are mainly two logic part: logic of pedestrian and logic of trains.

Logic of pedestrian: The pedestrians are divided into two group, which are pedestrians go to the trains and pedestrians come out from the trains. "PedSourceWest" and "pedSourceEast" separately represent people comes from west escalator and people comes from east escalator both of the two groups are included in pedestrian go to the trains. The train doors above are classified as "go to train1" in the logic, relatively the train doors below are classified as "go to the train 2" in the logic. According to the calculated result, the possibility for each pedestrian go to the door1 is 66% and the possibility for the door2 is 34%.
Logic of trains: There are two different train running tracks in the logic, "trainSource1" is the train above, "trainSource2" is the train below. For the whole train movement process, four main actions are: "train move to stop", "train unload", "train upload" and "train move to exit". The developer adjust the speed of train during the period based on the real rate and frequency of train movement. (The frequency of train is 4 minutes on the daily, which will change into 3 minutes during the rush time).
3.2.3. Ningbo Qian Hunan Road crossroads

The 2D animation:
The developer added the satellite map image of crossroad in the 2d animation as the background. Then drew the crossroad and define the running track of cars in the animation at the same time.

The 3D animation:
The users can choose different camera views which have already been set in the animation. Focus on different objects, traffic lights also visible in the 3D animation.

The logic:
The logic is mainly divided into four parts: cars from the north, cars from the south, cars from the east and cars from the west. The developer classified them into four different groups. Then distinguished the potential directions them may choose for each group. For instance, for the cars from the north, which comes from reverse lane of vertical road and the potential roads which may goes including the south of vertical road, the west direction of horizontal road, the east detection of horizontal road and turn around to the north direction. The developer using the collected data to simulate the possibility of cars track in the logic.

Figure 7. The 2D animation

Figure 8. The 3D animation

Figure 9. The logic

4. Conclusion
Summaries be indicated from three significant simulations:
4.1. Ningbo Incity Mall

4.1.1. The design leak of entrance1 (South Entrance). When pedestrian volume reaches 80% of maximum capacity, the overcrowding may happen in the south entrance.

4.1.2. The design leak of toilet. There should add one more toilet around the left upper area of the first floor at least. Because the location of the original toilet is not suitable for customers or staff members in mall.

4.2. Ningbo Subway of train station:

4.2.1. The problem with the train frequency. During the rush time, although the train frequency is accelerated to 3 minutes each turn, there still happen overcrowding problems, especially for the direction to the GuLou station. Base on the analysis, set the frequency as 2 minutes during the rush on the lane to the GuLou station will reach the maximum cost performance.

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