A Micro Traffic Simulation System and Visualization Solution Based on Cellular Automata

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Abstract. Micro-traffic simulation model is a research hotspot in the field of transportation. In order to solve the problem of software applicability caused by further subdivision in the field of traffic research. This paper introduces a micro-traffic simulation system and visualization solution based on cellular automata, and explains the software architecture and software design process in detail. The software can be applied to different types of road networks and supports parameter adjustment and web-based visualization to adapt to different requirements. The experimental results show that the Open source features of the model makes research easier to customize requirements.

Introduction

Traffic flow model can be divided into submicroscopic model, microscopic model, mesoscopic model and macroscopic model [1]. Previous studies mainly focused on macroscopic model to discuss the changes of traffic flow and density. And microscopic traffic model can calculate the coordinates of each car, speed and other characteristics, thus can provide detailed information for traffic management and simulation. The urban traffic control is the main application field of microscopic traffic simulation model. At present, more than one hundred micro simulation model, the microscopic traffic simulation software and a variety of commercial, most can the urban traffic simulation. But since most software customized ability, lack of depth which built by the unknown, some specific parameters in the model the behavior of the vehicle model is fixed, the closed source code features allow researchers when facing some special requirements will be in trouble. For some researchers, building a model that meets the requirements takes a lot of time. Based on these backgrounds, we propose a micro model based on c++ implementation, which has good customization characteristics, and can be further redeveloped in depth on visualization to achieve different requirements. The structure of this paper is divided into four main parts. The first part, "road network construction", mainly explains the detailed structure of the road network built in the software model and the implementation of the customized road network solution. The second part, "vehicle behavior model construction", mainly describes the logic of how vehicles are represented, how vehicles as cellular automata move under certain rules, and how they choose paths. The third part, "visualization," will tell you a simple and flexible solution. Finally, the paper explains the deficiency of the model and the next step.

Establishment of Road network

Urban traffic road simulation model is an abstraction of the traffic system according to the characteristics of simulation technology, including the description of the elements of the road traffic system, the interaction between the elements and their change process. Sections, intersections, lanes, signal lights and other elements are represented as a combination of squares in this model. In order to realize the complex and variable road network model, the object-oriented design of the factory mode is introduced in the programming process to package the road sections, intersections and signal lights into one instance. Actual maps can often be mapped into multiple matrices. Each position in the matrix is an object that can be initialized based on actual parameters. Considering the controllability of semaphore, timing scheme is used as the initialization parameter for timing and control.
Parameter of the the $i$th signal lamp:
- Red light timing: R_Time
- Green light timing: G_Time
- Yellow light timing: Y_Time
- Phase difference: offset

For an intersection on the map plane, it has a unique number, such as (x, y), so each section will be represented as a directed path between two intersections, corresponding to lanes in opposite directions respectively. Specifically, each section will be divided into entrance section, exit section and free exercise section. According to these limitations, a representative network will be established.

**Construction of Vehicle Model**

Urban microscopic traffic model regard the solution as the goal which is the movement of individual vehicles on the urban road network space, the core function of the model is to describe the relationship between the target vehicle and its surrounding traffic environment, that means how the surrounding traffic environment caused or determines the driving behavior of the vehicle[4]. While the vehicle traffic environment including the target car around the vehicle, target vehicle's road facilities and traffic rules.

**NS Rules**

In the vehicle model implemented with cellular automata[2], NS rule is used, and every vehicle is changed in parallel according to this rule.

In general, this rule can be described as:
(All vehicles are updated according to the following rules from time $t$ to time $t+1$)
a) **acceleration**: (based on the tendency of vehicles to travel at maximum speed):

$$v_x \rightarrow \min(v_{n+1}, v_{max}).$$  \hspace{1cm} (1)

b) **deceleration**: (deceleration measures taken to avoid collision)

$$v_n \rightarrow \min(v_n, d_n).$$  \hspace{1cm} (2)

c) **random deceleration**: (corresponding to the deceleration caused by various uncertain factors in reality):

With probability $p$, $v_n \rightarrow (v_n - 1, 0).$  \hspace{1cm} (3)

d) **movement**: (position at the next moment)

$$x_n \rightarrow x_n + v_n.$$  \hspace{1cm} (4)

Here:
- Time, space and vehicle speeds are discretized to integers
- Roads are divided into cells that are owned or not owned by vehicles
- The vehicle's speed is between $0 \rightarrow v_{max}$
- $x_n, v_n$ respectively express the $n$th car position and speed,
- $d_n = x_{n+1} - x_n - 1$ represents the distance between $n$th car and $n + 1$th.

**Rules of Behavior Related to Road Networks**

In particular, consider that roads are logically represented as small grids, the rules of movement of vehicles in particular areas need to be specified separately.

![Figure 2. Rules for straight, turn left, turn right and turn-off lanes.](image)

Certain paths are specified under the actions of going straight and turning left, right and turning around, as shown in the figure[3].

**Path Selection Behavior**

According to OD, vehicles choose the shortest movement time route, which can be determined before simulation start, also can be determined in real-time. In the process of dynamic route choice model is memory-saved, but it takes large amount of calculation. Before-simulation route choice model save all the detailed route in database, which has no need for real-time calculation[6], but it takes up more internal storage. In this microscopic traffic simulation model dynamic path selection is used.
Visualization Part

Thanks to the development of web applications, charts (especially maps) are now better represented in their own right than in the interfaces that come with PC systems. In this research, considering the requirements of presentation form, we adopted Openlayers (OpenLayers is an open-source JavaScript library for displaying map data in web browsers as slippy maps.) for development, so consideration to combine map with free reality and take advantage of lightweight features of web pages. In this way, we minimize the front-end coupling of the program. The visualized part of the program contains only a small amount of code to process the input and output, and all the simulation logic is implemented in c++ code.

Application Scope[5]

Experiment results show that the software can well meet the following simulation requirements.
1) to evaluate and predict the erection of Bridges and expressways, and the establishment or cancellation of road and bridge control facilities;
2) to evaluate and predict the capacity and service level of the road;
3) evaluate and predict traffic control strategies;
4) carry out accident simulation to analyze the formation, propagation and dredging process of the obstruction;
5) embed the traffic flow model into other tools and use it as a sub-model;
6) providing travel information guidance, online optimization;
7) traffic managers training.

Conclusion

Urban traffic control, and planning is the main application fields of microscopic simulation model, therefore it is necessary to establish urban microscopic traffic simulation model systematically. In this paper, the city of microscopic simulation model, according to the results, to road traffic capacity, road network planning, evaluating and forecasting the traffic rules, traffic control strategy, for researchers, policy makers provide good decision support. The next stage, add a non-motor vehicle model will be considered in the model, and add a wider variety of built-in types of roads, to make it more in line with the characteristics of urban traffic, different countries Consider using the more abundant interface functions of the amount of Echart as a data visualization tool, in line with higher performance.

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References


