Design and Development of Traffic Evacuation Software Based on Micro Simulation

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Abstract. In order to better evacuate residents in the case of regional disasters and ensure the safety of the lives and properties of regional residents, we designed and developed traffic evacuation simulation software under various disasters based on microscopic simulation. The system adopts C / S architecture, MVC design mode, and has the functions of road network simulation, intersection simulation, vehicle operation simulation and signal control simulation. It is loaded through the simulation program, compares different evacuation schemes, optimizes the setting of space division, path division, signal Phase and signal phase. Provide reference basis for the relevant departments to evacuate residents.

1. Introduction
In the emergency evacuation scene of vehicles in a local area under the action of urban disasters. In a short period of time, the contradiction between traffic supply and demand has intensified. The vehicles in the area are evacuated to the peripheral security area. It is very easy to cause serious conflicts at the intersections, causing the intersections, road sections and even local areas to be paralyzed, and the evacuation efficiency is very low. Untimely evacuation of vehicles can easily lead to loss of personnel and property, and can also cause unnecessary secondary injuries. Through the development of traffic evacuation simulation software based on microscopic simulation, emergency evacuation management decision-making under various disasters is realized. The simulation software includes simulation data input, real road network simulation, intersection channelization simulation, vehicle operation simulation, signal light control strategy simulation, evacuation area peripheral vehicle simulation functions and the most important evacuation plan set verification, comparison and optimization functions. Provide information support and decision-making schemes for traffic evacuation under multiple disasters in local areas of the city. The target users of this simulation software are mainly targeted at road network level operation managers.

2. System Architecture Design
The software adopts C / S (Client / Server) architecture design, which divides the system into two parts: client and server. Using MVC design mode, the server-side logic layer, view layer and data layer are separated to increase the flexibility of the program.
3. Functional Design

Traffic evacuation simulation software aims at the shortest overall evacuation time and maximizes the maximum potential of available data, road networks with different topologies, intersections with different channelization methods, vehicle evacuation paths, and signal light control schemes.

3.1 Road Network Topology Simulation

Function description: The presentation of the road network topology structure from simple to complex, including a more regular, easy to observe, and easy to control Manhattan grid network, the actual network topology structure based on real coordinate data.

Input data: comprehensive traffic disaster data, traffic history data, actual road network data.

Output data or display form: The simulation interface can display the simulated road network topology structure, including the length of the road section, the number of road sections, the form of intersections (several intersections), the number of intersections, etc.
3.2 Intersection Simulation
Function description: Corresponding to reality, you can choose different types of intersections, including corner intersections, T-shaped intersections, cross-shaped intersections, etc.

Input data: number of lanes, intersection type, intersection channelization method, etc.

Output data or display form: The simulation interface can clearly show different types of intersections, as well as the internal channelization of the intersections and the way of dividing internal lanes.

![Intersection simulation interface](image)

**Figure 4.** Intersection simulation interface

3.3 Simulation of Vehicle Operation Mode
Function description: Load the vehicle on the simulated road network with different loading rates, and let the vehicle run on the road network based on the NS rules. At the beginning, all vehicles are warmed up under the same conditions of the intersection signal timing scheme. The vehicles autonomously adopt lane changes and overtaking according to the designated destination. After the evacuation starts, all vehicles start emulation of emergency evacuation according to the different evacuation plans specified later, including sub-area evacuation, different signal control plans, and different vehicle path planning.

Input data: different vehicle loading rates, different vehicle navigation modes, vehicle lane changes, overtaking and other microscopic movements.

Output data or display format: The simulation interface can clearly see the operation of the vehicle at different loading rates, including the complete process of the vehicle from the specified start point to the end point, including queue delay at the intersection, affected by different signal control solutions at the intersection Various steering movements, as well as overtaking and lane-changing behavior on various road sections (more than two lanes).

3.4 Signal Control Strategy Simulation
Function description: The signal control method is one of the most effective methods during emergency evacuation. Therefore, in order to avoid the short-term delay caused by the conflict between different vehicle flow directions in the same phase and make full use of the effective time of different phases, avoid the green light empty. A variety of conflict-free flow direction combinations of different types of intersections are matched to different phases of signal control, and then different phase sequences and different phase durations are set according to the calculation of evacuation flow.

3.5 Evacuation Strategy
Function description: The ultimate goal of the software's evacuation strategy is the shortest evacuation time, so different evacuation strategies can be formulated for vehicles, such as autonomous, induced, and controlled.

Input data: Different evacuation strategies correspond to different inputs. For example, autonomous
evacuation corresponds to formulating a path planning model based on the shortest distance and a path planning model based on the shortest time.

Output data or display form: The simulation software can show the total evacuation time of all vehicles in the disaster area to the safe area under different evacuation strategies, which is also convenient for subsequent evaluation, comparison and further optimization of each evacuation strategy.

3.6 Generation and Comparison of Evacuation Plans
Function description: Each evacuation strategy corresponds to an evacuation plan. The evacuation plan includes the wayfinding and navigation methods for vehicles under different vehicle loading rates, the evacuation of vehicles by area or global evacuation, and the difference in signal phase sequence.
Output data or display form: record the parameters of the total evacuation time, vehicle loading mode, vehicle operation mode, signal control mode and other parameters corresponding to each evacuation plan to form various evacuation plans.

3.7 Simulation Visualization
Function description and display form: The realization of all the above functions can be visually displayed through the simulation visual interface. For example, road network topology, vehicle operation and evacuation process, vehicle queue delay at the intersection, the equivalence of the vehicle from the beginning of the evacuation to the evacuation to the safe area can be accurately positioned on the visual interface.
4. Technical Realization

Based on microscopic simulation, the software for traffic evacuation simulation under the action of multiple disasters uses real road network data, comprehensive disaster data, etc., combined with cellular transmission automaton theory and shortest path theory, to study dangerous areas during emergency and emergency. When the contradiction between the supply and demand of vehicles and roads intensifies, how to coordinate and optimize the evacuation of vehicles to a safe area as soon as possible under the conditions of limited infrastructure such as existing roads and signal lights. Its essence is to develop a set of simulation programs based on micro-simulation, multi-scenario and multi-dimensional simulation of real disaster conditions, which can restore and reproduce the real and possibly predicted scenarios as much as possible. It provides a very effective means for reference and utilization for traffic evacuation management decision-making. And this software is not based on other traditional traffic simulation software, but conducts comprehensive simulation research from scratch, which has great research value and practical significance.

4.1 Phase Coordination to Avoid Conflicts

The intersection in the urban road network is undoubtedly the bottleneck area in the entire road network structure. Most of the delays and conflicts are generated when the traffic flows merge or diverge in all directions. Reducing delays at intersections is one of the key functions of this software. For this part, the realization of the software is mainly based on the combination of conflict-free flow directions at the intersection. For example, in the east-west direction at the intersection, the left turn of the west entrance and the straight travel of the east entrance will create a flow direction conflict at the intersection, resulting in uninterrupted vehicle operation. In order to avoid unnecessary time loss in this part, we separate the two flow directions in time, and the corresponding implementation is that the combination of the two flow directions does not appear in one signal phase at the same time. And so on, we have studied a total of 169 conflict-free combinations, and through simulation, a total of 64 can be controlled by the AB signal phase of the signal light. This method greatly improves the utilization of each signal phase and reduces unnecessary time loss, which has great practical significance.

4.2 Space Limitation, Shorten the Path

The software also compares the evacuation of vehicles in the disaster area under the action of multi-hazards in all planes and the evacuation in different regions. It was found that each evacuation strategy has its advantages when the loading rate of the vehicle is different. In full-plane evacuation, vehicles can freely choose a suitable evacuation path, but some vehicles may have a longer path in the evacuation path planned for it, which causes more interference to other vehicles due to the wider area crossed. For evacuation by area and quadrant, the whole plane is divided into different areas, and each area adopts its own evacuation strategy, so that not only can the traffic flow and disaster degree of different areas be selected, but also the evacuation priority can be selected. It can also avoid some vehicles traveling a long distance to the evacuation exit, which is also an important means to ensure the overall evacuation efficiency, so that the flow direction of the whole plane tends to be balanced, and serious congestion will not occur. After several attempts to divide the area, it is proved that this function can indeed have a proven impact on the evacuation of the vehicle under a certain loading rate.

4.3 Vivid Simulation and Visualization

When local cities suffer from disasters, the high uncertainty, high degree of hazard, and high degree of urgency for these types of events have caused a sharp drop in the accessibility of the transportation network, reduced travel time reliability, and have Highly centralized. The phenomenon of "single source and multiple sinks" is serious, and vehicles almost flood into the safe area at the same time. Therefore, it is necessary to simulate, observe, and study the movement state of the vehicle when an emergency occurs. The vivid image visualization can clearly capture the movement characteristics of the vehicle, which helps to study the external behavior of the traffic flow to the internal law under such extreme conditions, find problems in time, and formulate a reasonable rapid evacuation path accordingly. And all the management and control schemes, path planning schemes, etc. can also show the effect in time, which is the basis of this software and one of the important functions of this
software.

5. Summary
The research and development of software for traffic evacuation simulation under the effect of multiple disasters based on micro-simulation provides guarantee for the property and life safety of residents in the area. By implementing the functions of road network simulation, intersection simulation, vehicle operation simulation, and signal control simulation, it provides a platform for the comparison and optimization of the evacuation plans of relevant departments.

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7. References
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