Route Selection Behavior Analysis and Model Based on Scratch Degree

Ying Yang1,*, Shuaihu Yang2, Min Feng3 and Ying Teng2
1School of Computer and Electronic Information, Guangxi University, China
2School of Mathematics and Information Science, Guangxi University, China
3School of Journalism and Communication, Guangxi University, China
*Corresponding author e-mail: yingy2004@126.com

Abstract. Existed many transportation information service system does not take into account the overall operation of the road network and the real-time intelligent guidance to drivers. This paper focuses on the analysis of the important factors such as the scratch degree and the travel time that affect the driver's route choice behaviour, and the mathematical model and relative evaluation of the scratch degree are established. On this basis, combined with the multi-agent model method, the route selection behaviour model based on scratch degree under road network information is constructed, and the Repast S tool is used to carry out the simulation analysis. The analysis results show that the model can real-time optimize the route selection, reduce the driving time, effectively avoid the probability of congestion and scratch collision and improve the safety of travel.

1. Introduction
It is a hot issue in intelligent transportation services research [1] that how to release effective guidance information according to the driver's behavior characteristics, to help choosing the path effectively, avoid congestion and guide parking rationally. With the rapid growth of the number of motor vehicles and drivers, the road traffic collision accident has gradually increased, especially during rush hours. If these motor vehicles are not leaded away in time, it may lead to more serious traffic jams. According to the yearbook statistics for Command and Dispatch Center in Beijing Public Security Bureau [2] as Figure 1, the motor vehicle collision accidents involve scratch, rear-end, unilaterally and others, the scratch collision accounts for about 82.6% of the total number.

![Figure1. Pancake diagram of the accident ratio](image)

The scratch collision usually occurs in the intersection, the ring or crossing road and the entrance or exit position of highway. The involving section area is larger, the "Butterfly Effect" of the Scratch is larger, and the affection of traffic and security is larger.
Jeffrey L. Adler [3] proposed a "principle" negotiation model by multi-agent to achieve more effective distribution of road network capacity in time and space. Zhang Wei [4] studied the route choice and adjustment behavior of travelers under ATIS condition, and constructed a traveler route choice model. Gao S [5] points out that the driver's search and use of traffic information will be constrained by travel time and cognitive ability, and a cognitive cost model of information search is proposed to analyze the relationship between traffic information search and path selection. At present, most of the research on personalized information service system does not take into account the overall running condition of the road network and the driver's real-time intelligent guidance.

This paper analyzes the important factors such as the scratch degree and driving time and establishes a mathematical model. On this basis, combined with multi-agent modeling method, the route selection model based on scratch degree under road network information is constructed, and Repast S tool is used to carry out an example simulation analysis. The analysis results show that this model can effectively improve the traveler's driving time and safety, and avoid the chance of scratch collision. Especially when important events or emergencies occur, a large number of motor vehicles are clustered and rubbed, the chain collision and accidents lead to the "Butterfly Effect", and a large number of police forces are needed to maintain security. This model can realize the smart shunting intelligently in the peak or easy to scrape section, and give the driver the optimized route to reach the destination.

2. Analysis of route selection behavior based on scratch degree

In intersection or congested area, cars are prone to scratch, lead to traffic accidents or disputes and a series of impacts such as travel delays and traffic comfort. Therefore, this section focuses on the influence of scratch degree on path selection behavior under congestion. When a car is turning, the minimum turning radius relates to the vehicle length and the width of the turning channel. In the calculation, the vehicle's background is relatively congested and the speed is slow, so the influence of the centrifugal motion, the deformation tilt of the vehicle are ignored.

Set σ as the width of the obstacle on the inner bend; ∏ as Road width; ϕ as The distance between the obstacles on the inside of the car and the bend; R as Turning radius; L as car length; D as vehicle width; α as the deflection of the vehicle heading towards the geographical direction after passing the curve; ρ as the arc length of a curve crossed over the bend; l as the distance of two rounds between front and back of a vehicle; d ground clearance of the car chassis.

2.1 The evaluation model of the scratch on the bend road

Set the curved curvature of the curve Ω=α/ρ. The experience shows that when the internal wheel difference can’t be ignored when the Ω>0.18. The data of the vehicle model, width of the road, the width of the obstacle on the inner bend, the curve of the curve and so on are obtained by the camera of the corresponding path section. After drawing by function drawing tool, the function similar to the inside rear wheel track is selected. So we can get the relationship according to the geometric relation.

\[
ϕ=0.5(∏-D-σ) \quad (1)
\]

Due to the small lateral distance between vehicles on the congested roads, we usually have sharp turning on the corners, the inner wheel differential will lead to the phenomenon of vehicles and obstacles. After consulting the relevant information, we can see that the difference of the 4 to 4.5m long vehicles is 1m, the safe distance is no less than 0.6m. Due to x=ϕ-1, so we can get the score of the collision degree of the road section.

\[
a=1/x0.7495+0.2x+71.62 \quad (0<x\leq0.4) \quad (2)
\]

\[
a=73.6873-1/(0.8-x)0.7495-0.2(0.8-x)+2.0673 \quad (x>0.4) \quad (3)
\]

when Ω<0.18, the inner wheel difference can be ignored, that is ϕ=0.5(∏-σ). Take the above calculation for evaluation. When the route has multiple corners, that is

\[
a = \sum_{c=1}^{n} a_n / c \quad (4)
\]
Here \( c \) is the number of corners. When \( \phi < 1.2 \), distance is less than the safe distance, it is easy to have a scratch collision. Therefore, the score 75 is the critical value of the curve in the middle lane. If the curve is divided into the curve from very small to the curve participation calculation, the amount of data and the time of calculation will be greatly increased, and the internal wheel difference trajectory will become complicated. So in order to optimize the calculation, this section calculates the turning of many angles by the investigation and analysis. As the car owner drives, the cover of the front hood of the vehicle causes the blind area of sight line, so the downhill or the upslope can be visually different for the driver. In theory, the driver is difficult to see the distance between the inside of the curve and the car when the corner is downhill. Here is the experiment. At the same corner with the slope, a photograph was taken from the angle of the slope and the angle of the downhill, and the slope of 10 and 15 degrees was selected as the experimental independent variable. On the standard highway, the photos were taken and the two hundred owners watched by the photos at random. When the car owner feels that the car is turning, it will start with the turning curve. It is necessary to pay attention to whether or not the inside of the car and the corners are rubbed as the dependent variables of the experiment. After investigating the two hundred owners, the experimental data were aggregated and the survey result in Figure2 was shown. The mathematical expectation of experiments at $10^\circ$, $-10^\circ$, $15^\circ$, and $-15^\circ$ is respectively expressed, and $E_1=56.575^\circ$, $E_2=53.275^\circ$, $E_3=62.375^\circ$, $E_4=48.075^\circ$.

![Figure2. Data folding map of survey results](image)

It is not difficult to see that drivers will be more sensitive to the bend road because it's influenced by downhill on the field of vision. Therefore, in order to reduce the amount of calculation and the delay of information transmission, the road with a deflection angle of more than 45 degrees is defined as a bend.

2.2 The chassis scratch model of the upslope or downhill

The approach angle and departure angle represents the ability of vehicles to avoid collisions when they are approaching or leaving obstacles such as hills, gullies and so on. The greater the angle, the better the vehicle's passing capacity.

After obtaining the angle of the slope $\theta_1$ on the camera, the corresponding vehicle type can be found and the technical parameters are queried to get the corresponding angle (departure angle) $\theta_0$ of the vehicle, and the corresponding tangent value is taken. Because the distance from the common household model is 170~220mm, the shock absorber and the suspension system retract an average of 50mm when they are obstructed. When the difference between the close angle (departure angle) and the slope is zero after retracting, it happens to enter the slope safely. Its regression equation is $x=\tan\theta_0-\tan\theta_1$, $y=-2 \times 105(x-0.05)^3+75$. When the front wheel of the vehicle enters the downhill slope and the rear wheel does not enter, the vehicle head is pressed down, while the rear height is almost unchanged. The average arc length of the slope is 2 meters. When entering the downhill slope from the horizontal plane, the midpoint of the two wheels is nearest to the ground. According to the geometric relationship, we have the equation as follow,
As the suspension system causes the wheel to shrink, the chassis will drop and the road surface will be sundry. After many experiments, the following equations for evaluating the chassis wear \( y=75-(100d_{\text{min}}-5)\frac{3}{5} \) is obtained. The vehicle goes from level to downhill and then back to level. There are two opportunities to scrape the chassis (rear) and a chance to scrape the middle end chassis. So the scratch coefficient of the chassis is as follow,

\[
b=100-(100d_{\text{min}}-5)\frac{3}{15}-4\times10^5(x-0.05)\frac{3}{3}
\]

After the analysis of nearly 1000 domestic and foreign traffic crashes, about 67.4% of the accidents caused by the turning on the bend, the narrow road and other factors, the rest of the accident caused by the slicing of the chassis. After weighting, the scratch degree was obtained as follows:

\[
\mu=67.4\%a+(1-67.4\%)b
\]

After weighting the coefficient of friction, the corresponding critical value is obtained, and 75 is the critical value of the scratch coefficient. Therefore, when \( \mu>75 \), the vehicle owner would have a great chance to scratch through the path. The greater the value is, the greater the possibility of cutting is.

3. The Route selection model base on scratch degree

Combining with multi-agent theory, the paper considers the traffic elements in the traffic system as agent individuals such as vehicles, travelers, traffic managers and so on. Various agents can make certain responses according to the environment changes. During the trip, each travel agent can adjust the route on the way when every time arriving at an alternative intersection, the current better path selection based on the scratch degree and the real-time information. It not only considers the randomness of the transport system, but also ensures the possibility of driver path adjustment at any time.

The route selection model treats traffic manager as management Agent, and treats driver and vehicle as travel Agent. The management Agent gives leading information according to the status of the road network, which mainly a set of paths between nodes and a set of travel times of each path. And the travel time of the route includes the travel time of the relevant path nodes. The attributes of the management Agent mainly include the current predicted travel time \( T_{ij} \) and average driving speed \( V_{ij} \) of each path in the road network. Here \( T_{ij}=t_{i1}+t_{1k_2}+\ldots+t_{k_{n-1}k_n}+\ldots+t_{knj} \) is the sum of the current predicted route time from node \( i \) to node \( j \), and \( t_{k_{n-1}k_n} \) is the travel time between the intermediate node \( k_{n-1} \) to node \( k_n \). \( V_{ij}=v_{i1}+v_{1k_2}+\ldots+v_{k_{n-1}k_n}+\ldots+v_{knj} \) is the sum of the average running speed of every node from node \( i \) to node \( j \), \( v_{k_{n-1}k_n}=\frac{1}{m} \sum v_{k_{n-1}k_n} \), here \( v_{k_{n-1}k_n} \) is the average speed of the path between the intermediate node \( k_{n-1} \) to node \( k_n \), and \( m \) is the number of motor vehicles in the path section. The flow chart of the route selection model bases on scratch degree is shown in Figure 3.

When a traveler drives the car from a certain start node \( i \) to the destination node \( j \), the travel Agent has many optional paths to let the traveler intelligently real-time re-select according to the management Agent information and the degree of congestion, as well as the required time in the current road conditions. Let \( P_k=\{p_{k1},p_{k2},\ldots,p_{kj}\} \) be the path collection for the current node \( k \) to the target node \( j \), and \( T_k=\{t_{k1},t_{k2},\ldots,t_{kj}\} \) for the travel time corresponding to each path. The path re-chose for the travel Agent will be determined by the scratch evaluation value \( \mu \). If \( \mu<75 \) then the path needs to re-select because the scratch degree is very big, the probability of the scratch collision is the greatest and the traffic jams are the worst. The travel time will change. The total time includes the original time \( t_{k} \) which arriving at the current node \( k \), and the new time \( t_{kq} \) which arriving at the new chose next node \( q \) in path section.
Here $\mu$ is the critical value of scratch. Through the above mathematical modeling and relative evaluation analysis, value $n$ is 75. When $n<75$, it isn't serious to appear the phenomenon of scrape. Then the travel Agent follows the original route, and adjust the driving speed of motor vehicle according to the big or small value of $n(0<n<75)$ in the path section until next node. If node is $j$, it means the traveler arrives at the destination place.

4. Simulation analysis

Figure 4 is a road network abstracted from a certain section of a city including 9 nodes and 10 path sections through the simulation tool Repast S. The section length is expressed by the number of cells. Cell length is the minimum time headway, and each cell can only accommodate one travel Agent. Assume that the length of each section is 10 cells. Here, through node 1 entering, node 9 leaving as an example to analyze the effect on path selection and the influence of scratch degree in the simulation region.

The travel Agent enters the road network randomly from node 1. Figure 5 shows the vehicle distribution diagram through Repast S simulation, when simulation time tick = 200. From top to bottom in the figure is the distribution of vehicles from section 1 to section 10, where the black dots represent the vehicles, and the vehicles move from left to right on all sections of the road. Each vehicle reaches the right node of each path section to determine which section to enter next. In the end, drive from path 8 or path 10 to node 9 to leave the road network. It can be seen from figure 5 that the distribution of vehicles on each path section is basically uniform and avoid a crowd of cars to a particular section of the road. It is shown that the information given by this model to travel Agent can help alleviate the traffic jam and avoid the safety problems caused by scratch.

Under different value of scratch, the comparison of travel time between the route selection model and without model is in Table 1, when $n=75$, it is indicated that there are varying serious degree scratch collision or traffic jams at the driving node. And the travel time under the guidance of our model only needs $1796 \div 4435 = 40.5\%$ than that without the model’s guidance. When $n=45$, it indicates that there may be different degree of scratch or traffic jams at the traffic node. And the driving time under the guidance of the model is obviously less than that without the model guidance, only needs the time as $1172 \div 2031 = 57.7\%$. But when $n=5$, it shows that there is almost no scratch collision or traffic jam at the traffic node and the travel time is only $72.7\%$ to the time without our model because the pre-select route by the negotiation between the travel agent and management agent.

*Figure 3. Route selection model*
The results show that the route selection model by scratch degree can reduce travel time to a greater extent.

![Figure 4. The road network simulation](image)

| Table 1 The comparison of travel time |
|--------------------------------------|
| Scratch value | Driving time (s) under this model | Driving time (s) without model |
|---------------|----------------------------------|-------------------------------|
| 75            | 1796                             | 4435                          |
| 45            | 1172                             | 2031                          |
| 5             | 817                              | 1123                          |

5. Conclusion

How to release effective guidance information according to drivers' behavior characteristics, guide vehicle owners to choose effective paths, avoid traffic jams and ensure traffic security are the hot issues in the research of intelligent transportation at present. In this paper, we establish the path selection model base on scratch degree and carry on Comprehensive evaluation analysis, combined with multiple agent model method. Through simulation analysis, it shows that the method can reduce the travel time to a greater extent, optimize the route selection behavior of the motor vehicle, avoid the traffic jams caused by the scratch, and improve the safety of driving.

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References

[1] ZENG Ying, LI Jun, ZHU Hui. Passenger route choice behavior on transit network with real-time information at stops[J]. Journal of Computer Applications. 2017, 33(10) : 2964—2968
[2] Zhu Baohua. Beijing Public Security Bureau Command and Dispatch Center Yearbook [Z]. The command center of the Beijing Municipal Public Security Bureau of Traffic Management, 2015, 1: 115-119
[3] Jeffrey L. Adler, Goutam Satapathy, Vikram Manikonda, Betty Bowles, Victor J. Blue. A multi-agent approach to cooperative traffic management and route guidance[J]. Transportation Research Part B. 2003, 39:297~318
[4] ZHANG Wei. Research of traveler’s route choice behavior under ATIS. Computer Engineering and Applications, 2017, 49 (13) : 234-236.
[5] Gao S, Freijinger E, Ben-Akivat M. Cognitive cost in route choice with real-time information: An exploratory analysis [J]. Transportation Research Part A, 2013, 45(9):916-926.
[6] SHI Lu. Study on Travelers’ Route Choice Behavior under Guidance Information[D]. Chengdou: Southwest Jiaotong University, 2016.