Designing A Traffic Circle

Abstract

Traffic circle plays an important role in today's transport circle. The rational design of the roundabout is important to alleviate the increasingly serious traffic pressure. Our goal is to build a model program to make the best choice to control traffic flow around the roundabout.

We builded a model to analysis the three main parameters of traffic flow just traffic flow rate, speed of vehicles and transport capacity, then we got the main controlling factors, following that we took full account of these factors to build another model for small roundabout without traffic lights and larger roundabout with traffic lights separately and gave the optimal design.

In case one ,we discussed about small roundabout and got conclusion that an appropriate increasing in motor vehicles around the island , reasonable reducing the radius of the island center, and provided a rule of priority for vehicles can improve the traffic capacity of the roundabout, indirectly realized the optimization of traffic flow control .

In case two, we discussed about larger roundabout with traffic lights and made good use of "Second- left Turning Control Method" to optimize the space around the island. And then we set the fuzzy controller for traffic lights to control the length of the green light time .then we can combine the time and space rationally and give optimized choice to make good use of then all. And through a special case analysis we verify the efficiency, flexibility and rationality of this approach.

In addition, we thought about setting the Dynamic lane approach. We wanted to ease and optimize the traffic flow through timely adjustments of the function of the lanes. This question had the merit for further discussion.

Content

1 Background

Traffic circle means to set an island at the central of the intersection. Because the traffic circle has many advantages, no matter in the countryside or the cities around, the roundabout will have the useless, it has long been an important crossroad .The roundabout can connect many multiple sections in different direction. All the vehicles around the center island drive on one-way traffic, and thus can be continuous through the intersection, they can help to avoid cyclical obstruction and greatly reduce the intersection conflict points to improve the traffic safety and the continuity of intersection. Besides, roundabout which is always decorated by trees and flowers can also beautify the environment.

But with the increasing demand for urban road traffic, the roundabout' capacity is or will be limited. Many of the original traffic capacity of the roundabout cannot meet people's needs, traffic problems have become increasingly acute, and some important roundabouts even have become the network traffic flow bottlenecks.

Full and effective usage of the roundabout's time and space resources, and maximizing intersection capacity is the goal of our research, seeking a reasonable solution to traffic problems of the roundabout appears to be particularly effective way of pressing. However, due to shift in traffic around the island Department caused the conflict between traffic, intersection, traffic diversion, such as running behavior. Therefore, we have to study this issue seriously, and strive to design an optimal control model.

Our mission is to further exploring something about the roundabout, and gives analysis to the main factor on the impact of the research to roundabout's capacity. The establishment of a model can guide us how to choose the right program and the optimal control of traffic flow around the roundabout.

2 Symbol Explaining

Traffic flow :means automobile road for a continuous period in the formation of traffic. A broad sense also includes other vehicles, traffic and pedestrian flow.

Traffic flow rate :traffic flow in unit time through the road section specified the number of vehicles, units are vehicles / hour;

Traffic flow speed: or velocity, that the processing speed of traffic flow, unit is m / s;

Traffic flow density: said capacity to express the degree of density of traffic flow, that is, per unit length of road vehicles containing the number of units are units / km.

3 The Analysis of The Roundabout

3.1 Interpretation of Traffic Flow

Traffic flow means automobile road for a continuous period in the formation of traffic. A broad sense also includes other vehicles, traffic and pedestrian flow. In a certain period of time without the effects of horizontal cross-sections the traffic flow is a state of continuous flow; in the face of the junction signal controls showed intermittent flow state. Quantitative description of traffic flow can be used three parameters: ① Traffic flow rate; ②Traffic flow speed; ③ Traffic flow density.

The relationships among the three parameters are: Traffic flow rate equals to traffic flow speed and traffic flow density. When the few vehicles on the road, the driver can choose a higher speed, higher speed traffic flow at this time, Therefore, the traffic flow is also relatively small. With the increasing of vehicles on the road, traffic capacity increases, the speed of the vehicle subject to the constraints before and after the vehicle has decreased, velocity has reduced.

So the optimal control of the traffic flow can be changed to the control of the traffic flow rate, traffic flow speed and traffic flow density.

In practice, it is difficult to control the whole traffic flows. So this parameter is not controllable, we have adopted in the model to analyze of other two parameters for different traffic flow by using a different program to control the traffic flow.

Through the analysis of the affected traffic capacity and traffic flow speed, we derived from single lane and multi-lane traffic capacity and the speed of traffic flow to get a formula, and then discuss it to analysis the main factors of imports capacity of the roundabout and transport flow speed.

3.2 The Analysis of the Factors of Transport Capacity

Since the roundabout appear in the United Kingdom , France at the

beginning of last century, people have been exploring the model of the roundabout's transport capacity .Although there are so many models, but in whole, it mainly based on three theoretical foundation[1]. The first one is the Interweaved Theoretical Model, reflect the roundabout's capacity by the maximum flow of the intertwined flux, the typical representative is the Wardrop Formula; The second category is a reflection of the regression model of the relationship between circular flow and the entry capacity . The third category is based on the Space – Acceptance Theory. Use the maximum entry flow capacity to reflect the transport capacity of the roundabout.

After the contrast of these three theories , we choose the Space – Acceptance Theory to further our discussion on the roundabout's accurate calculation of the transport capacity.

The 'Space – Acceptance Theory' means the vehicle can enter the lane if there is an interval which is above the maximum of the critical gap, otherwise, they must wait.

3.2.1 The Theoretical Transport Capacity Model for a Single-lane

The roundabout's 'Space – Acceptance Theory' model comes from the queuing model of two interacted traffic flow. As there are no overtaking behavior, we may consider the time between the headway of two vehicles subject to shift negative exponential distribution [2] .

At the roundabout where there is only one lane, the probability when the

Interspaces of vehicles in the roundabout are less than the critical gap t is:

$$H(t) = P(T \le t) = F(t) = 1 - \alpha\lambda e^{-\lambda(t-\Delta)} \quad (1)$$

in which λ is defined as $\lambda = \frac{q\alpha}{1-q\Delta}$(α:Free traffic flow in vehicles scale factor's : traffic flow in the Roundabout (vehicles / s))

the vehicle through the importing lane to enter roundabout comply with such an access rule that the first car to determine whether there is a gap greater than the critical gap of T , if there were then inserted , the follow-up vehicles enter after the vehicle in front has inserted, and then according to the remaining time to determine whether follow-up time greater than T0, if there is with the progressive. So in a roundabout driveway vehicle gap has exactly k units within Road vehicles imported into the traffic circle the probability is:

$$P(k) = H(T + kT_0) - H(T + (k-1)T_0) \quad (2)$$

The type (1) into type (2):

$$P(k) = \alpha e^{-\lambda(T+(k-1)T_0-\Delta)} - \alpha e^{-\lambda(T+kT_0-\Delta)} = \alpha e^{-\lambda(T+kT_0)} e^{\lambda\Delta}(e^{\lambda T_0} - 1) \quad (3)$$

The type (3) into the type $C = q\sum_{k=1}^{\infty} kP(k)$

at this time capacity to be:

$$C = q\alpha e^{-\lambda T} e^{\lambda\Delta}\left(e^{\lambda T_0} - 1\right)\sum_{k=1}^{\infty} k e^{-\lambda k T_0} = \frac{q\alpha}{1-e^{\lambda T_0}} e^{\lambda(\Delta - T)} \quad (4)$$

3.2.2 The Verification of Theoretical Model

The parameters in the theory T, T0, Δ is measured with the Siegloch Methods [3],they are 6s,2s and 3s. Figure 1 records a single carriageway in relation to traffic capacity theory of value

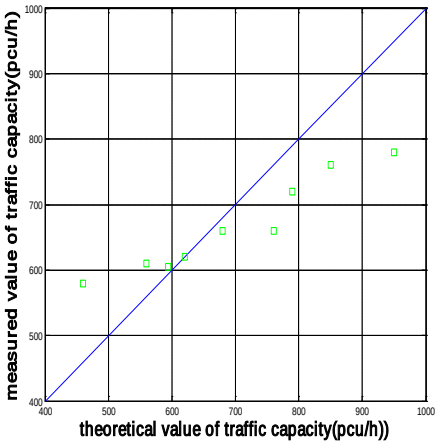


Figure1. a single carriageway in relation to traffic capacity theory

and the measured value. From the above, when the traffic flow is small, the measured value is smaller than the theoretical value, primarily due to higher speed at this time, the larger the value of critical gap, traffic volume, the measured value is larger than the theoretical value, mainly due to the lower rate of the circular flow of traffic at this time , andatory increase in the proportion of interspersed, the smaller the value of critical gap, In fact, due to flow into the ring with the circular flow of mutual influence, the actual flow of imports lane cannot be maintained at a significant higher time value. Capacity and low capacity study for no practical significance. As a result, the results validate the theoretical ideal.

3.2.3 Analysis of Theoretical Model

The influence of the traffic flow to the entry traffic capacity

In the shift of the negative exponential distribution, $\lambda = \frac{q\alpha}{1-q\Delta}$,if type it in formula (4), will get a very complicated model .Some scholars [4] consider α as 1-qΔ,then get little

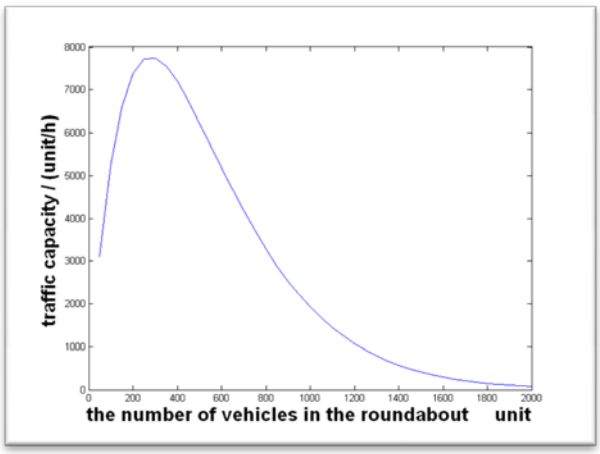


Figure2 . Entry capacity variations with different number of vehicles in the roundabout

influence. But it greatly simplifies the calculation of λ. Use the Matlab to make the import capacity of the vehicle C with the number of vehicle q and the trend is shown in Figure 2. Here

for T = 4s, T0 = 2s, and set the minimum headway Δ = 1.5s.

Analysis of Figure2, along with the increase of the number of traffic flow in the roundabout, the entry capacity has a maximum value, it's very important to control the traffic flow in the roundabout for the traffic capacity.

- **The Influence of the Minimum Length Between Headway and the Entry Traffic Capacity**

the minimum length between headway and traffic flow in the roundabout to the entry traffic capacity influence

The entry traffic capacity with the increase in the number of vehicles of the roundabout to reduce, Seen from Figure 3, with

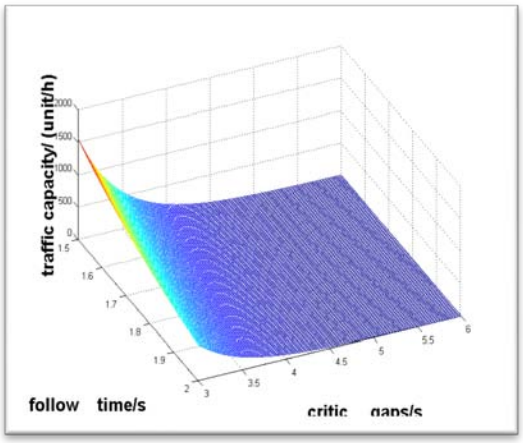


Figure 3 The influence of critical gaps and follow-up time on entry traffic capacity

the increase of the number of the traffic flow, the capacity decreased rapidly, and the traffic capacity with the increase of the minimum length between headway changes slowly. We also know from the analysis, the traffic in the roundabout have a great influence (impact) on the entry capacity (is very large); in the contrary, minimum length between headway has little influence (impact) on the entry traffic capacity.

- **The Influence to the Entry Traffic Capacity from Critical Gaps and Follow-up Time**

Another important factor which decided entry capacity is the vehicle number entering the roundabout, in specifically that is the critical gap and follow-up time of the vehicle on the entries road. Intuitive point of view, the

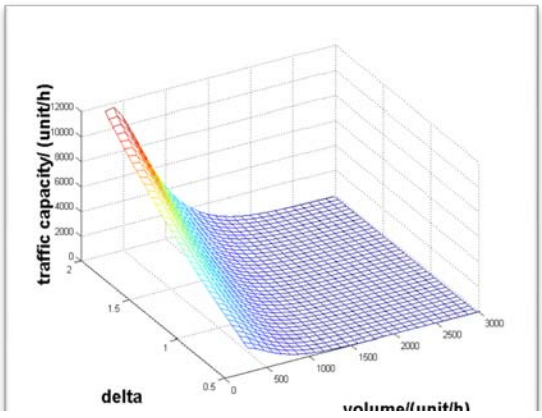


Figure 4 The influence of critical gaps and follow-up time on entry traffic capacity

critical gap and follow-up time (for) smaller, vehicles on Entrance Road (is) easier to seize traffic gap to enter traffic lane in the roundabout. Figure 4 shows both the impact of capacity (for Δ = 1. 5 s).

As can be seen from the diagram, Entry

Capacity reduce with the increase of the Critical gaps。Capacity with the critical gap in the rate of change than with the rate of change of follow-up time is much greater. The critical gap is a more important factor than follow-up time. This is also in related research [6]; the main efforts are concentrated in the critical gap estimates, but the reason for follow-up time often getting a certain experience. (Often take the time to follow up the experience of the value of a certain reason.)

3.2.4 The Entry Capacity of the Roundabout for Multi-lane

The difference between Multi-lane Road and single-lane Road is that vehicles on Import Road (the Multi-lane Road) must be able to insert (the) all the gaps in the driveway. Under normal circumstances, the import Road vehicles in each lane to enter the mainstream of critical gap and follow-up time is different, so to meet the import Road has exactly k vehicles to enter the mainstream, then we get:

$$P(k)=H(T1+kT_{01},T_2+kT_{02},\cdots,Tn+kT_{0n})-H(T_1+(k-1)T_{01},T_2+(k-1)T_{02},\cdots,Tn+(k-1)T_{0n}) \quad (5)$$

So we only need to come to the expression of H (t), some people have already conducted a research(6). It is presented in the following formula

$$C=\Lambda\prod_I \frac{q_i\alpha_i}{\lambda_i}\frac{e^{-\sum_i\lambda_i T_i}e^{\sum_j\lambda_j\Delta}}{1-e^{-\sum_m\lambda_m T_{0m}}} \quad (6)$$

With the same Analysis Method used in the Single-lane just as the analysis about the Single-lane, we also can draw the same conclusion about the multi-lane

3.3 Analysis of the Factors

1) to determine the radius of Central Island

In accordance with the requirements of the traffic speed, circular central island radius R is calculated as follows:

$$R = \frac{v^2}{127(\mu+i)} - \frac{b}{2} \quad (7)$$

Where: v for the Ring Road design speed, km / h, a general check road intersection speed of 0.7 times; b for lane width; I for the Bay Road slope; for the horizontal force coefficient. Lateral force coefficient is the vertical and horizontal to the friction coefficient of the composite indicator, to characterization of the actual vehicle braking or when skidding resistance of roads is a required value, generally in accordance with the design speed values, as listed in table 1 .

Table 1 generally in accordance with the design speed values

The velocity in the lane(km/h)	35	30	25	20
The coefficient of the side force μ	0.18	0.18	0.16	0.14

Bay Road slope i and the lateral force coefficient values determined by the type (7), we can see that the design of Central Road, the speed with radius R of the roundabout and the relationship between lane width b:

$$v = \sqrt{127 * \left(R + \frac{b}{2}\right) * (\mu + i)} \quad (8)$$

Central Avenue Road, the width of each vehicle including basic width and widening the width of two parts. The summarized in Table 2:

Table 2 Central Avenue Road, the width of motor vehicles and motor vehicle road surface width

The radius of the center island	50	45	40	35	30	25	20
the basal width of each lane	3.5	3.5	3.5	3.5	3.5	3.5	3.5
the additional width of each lane	1.0	1.0	1.3	1.3	1.8	1.8	2.4
the width of each ring lane	4.5	4.5	4.8	4.8	5.3	5.3	5.9
the total width of the Ring lane	14.0	14.0	14.9	14.9	16.4	16.4	18.2

Note [8] : ① Ring Road, the width of three motor vehicle lanes by arrangement; ② widened to consider the value of the ordinary car;

Central Road, left and right side of each curb with 0.25m.

Speedv $\propto \sqrt{R + b/2}$, the radius of the roundabout R is the impact on traffic flow speed, one of the main factors. Design of the size of the roundabout, the speed of traffic flow to their design of radius of the roundabout, and then through the radius in accordance with the relevant norms select or adjust loop road of the roundabout width.

2) The relationship between the traffic flow and speed of traffic flow[9]

$$C = \frac{1000v}{\left[\alpha\left(\frac{\pi v}{2v_f}\right)(T_{max} - T_1) + T_1\right]v + d_4 + L + \eta\sigma} \qquad (9)$$

Where: α time constant calibration; v for the current speed (km / h); Vf as a follow-up speed (km / h); Tmax was the largest follow-up time (s); T1 minimum brake operation time (s); L for small car length (m); d4 for the minimum safety distance (m); η speed influence coefficient of variance (s); σ for the velocity variance (m / s).

Discuss the relationship between the speed and flow, first select the largest follow-up time Tmax = 8s, the smallest brake operation time T1 = 1.0s, small car drivers L = 5m, minimum safety distance d4 = 1m, by calculating the different flow speeds value, has been the relationship between Figure 5.

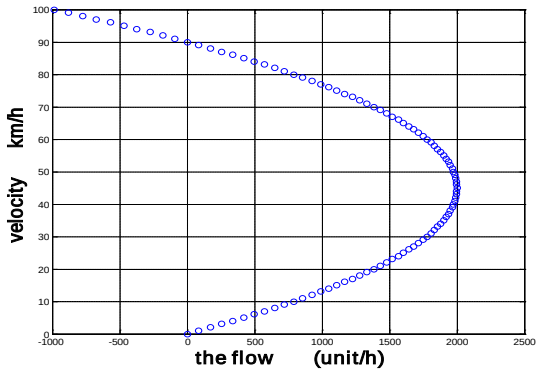


Fig.5 The relationship between the Traffic flow and speed of traffic flow

Theoretical speed - flow curve at a speed of 45. 0 km / h turning point took place, the maximum capacity 2001 unit/ h. From the speed - flow curve shape point of view the quadratic parabolic curve can be a very good match with the actual situation.

As can be seen from the graph, traffic flow speed and flow of the relationship between the existences of a large, traffic flow disruption to traffic flow rate is one of the important factors.

Combination of the above analysis, the impact on traffic flow speed of the main factors is radius of the roundabout itself and traffic flow.

4 Model Design

4.1 Model Analysis

Such as the above discussion, the control of traffic flow can be changed into the traffic flow, flow rate and the optimal control of the capacity.

In a certain place in practice it is difficult to control traffic flow. Based on this parameter it is not controllable, we in the model primarily through the capacity of the flow rate and an analysis of these two parameters for different traffic flow using a different program to control the traffic flow.

We use different models for traffic flow control:

- In small roundabout in (traffic generally not more than 2000 / h), can be set up speed limit in the license in the roundabout, "parking" signs or "given" signs to traffic flow through the plug on the roundabout;
- 2. In the large and medium-sized of the roundabout, the traffic in general over the roundabout's ability .So we always use the traffic lights to control vehicle behavior, thereby alleviating the roundabout the traffic pressure.
- 3. In some special areas, the use of traffic lanes is very uneven, we consider the use of advanced dynamic lane management technology, by setting the variable lane live according to the department of information and timely adjust the function of lane, which also can be greatly enhanced and lane the utilization rate of resources to achieve the purpose of improving traffic flow.

4.2 Case 1

4.2.1 Program Introduction

Major Research about the roundabout without signal lights. Through the impact of traffic capacity and traffic flow speed study analysis, derived from single lane and multi-lane traffic capacity and the import rate of traffic flow theory calculation formula, and change the formula to be discussed, analyzed the impact of imports of the roundabout and transport capacity flow speed of the main factors, so that we targeted, you can better adjust to these major factors that control traffic capacity and traffic flow speed, thus the purpose of controlling traffic flow. At the same time, the design of speed limit signs, "stop"

signs or the signs, such as line placement, and the radius of the roundabout, the roundabout width and other relevant design parameters to be determined.

4.2.2 Some Assumption of the Model

- We do not take into account of the irregular shape of the roundabout. It will be used as a circular only connect four ways from uniform direction.
- we assumed good weather conditions and road conditions, without giving effect to any extreme road conditions
- Consistency condition assumption that each driver in all similar circumstances has adopted the same act, we do not consider differences in the quality of pilots and their own factors on behavior.
- No consideration of the type of motor vehicles around the island .assume that all motor vehicles to achieve the same speed.

4.2.3 Case Building

Above (4.2) the theoretical model has identified the impact on traffic capacity and flow of the main factors, the main impact of these factors in the analysis to find traffic capacity and flow control methods and the design of the roundabout radius, roundabout width and other relevant design parameters.

1. The Control of Traffic Capacity

From the roundabout in the flow capacity of the relationship between imports on Figure 2 is known that in the traffic flow roundabout is small, as the traffic flow roundabout in an increase in import capacity can be enhanced very well. In reality the situation is more where the small flow can be a reasonable conclusion: the multi-lane Road than cycling roundabout is more conducive to improve the traffic capacity. Article in the design of the number of lanes in the roundabout, they generally center the roundabout as a bypass lane, the most outside one, as a right turn lane, middle lane for the use of vehicles intertwined; At the same time should also set up a dedicated non-motorized Road. As can be seen from Figure 2, when the traffic flow of the roundabout in a certain time, then a slight increase in vehicular traffic, the traffic capacity of the roundabout's rapid decline, while the practice has proved that the Central Road, Road, more than four motor vehicles, little increase in traffic capacity Instead, it

will create traffic chaos that is not conducive to safety. Therefore, the numbers of the lanes is generally 3 ~ 4.

Increase in motor vehicle Road Bay Road can be very well improve traffic flow of the roundabout, when the entrance of vehicles failed to timely access to the roundabout, the critical gap will increase, reducing the capacity. In order to allow more vehicles are able to access the roundabout at the same time, the increase in the entrance driveway in the roundabout, so that more vehicles can enter the roundabout at the same time, thereby increasing capacity.

2. Traffic Flow Speed Control

By the radius and the relationship between traffic flow velocity such as formula (8) an increase in radius can be increased traffic flow within the flow of the roundabout, in the selected cross-road gradient I, the horizontal force coefficient μ value, can be designed to speed traffic flow of the roundabout radius, can also be through the roundabout within a radius to define the scope of the traffic flow speed.

Increase in motor vehicle Road Bay Road can be very well improve traffic flow in the roundabout, when the entrance of vehicles failed to timely access to the roundabout when the roundabout's traffic flow rate increases, the traffic flow in the roundabout outside the lower velocity. In order to allow more vehicles are able to access the roundabout at the same time, the increase in the entrance driveway of the roundabout, so that more vehicles can enter the roundabout at the same time and thus control the traffic flow inside and outside the roundabout.

4.2.4 The Summary of Case 1

From the traffic capacity and traffic flow analysis of the speed control, we know that the changes in traffic flow through to the roundabout in the traffic flow roundabout radius of the critical gaps and adjustment to control

1 Traffic Flow Control

- roundabout in the flow increases, the traffic flow aroundλ the roundabout along with the increase of cars entering the roundabout outside the roundabout with the opportunity to decline, will lead the

cars in the roundabout plot set to make around the roundabout and external flow around the smaller.

λ critical gap increases, the internal roundabout between cars and trucks have a lot of gaps in the traffic flow in the roundabout within the small car in it have more opportunities to enter the roundabout, so that external traffic become larger.

- large radius, theλ traffic flow in the roundabout with the increase, but growth is very small, at the same time also increasing the car around the circumference of the roundabout, making the speed of traffic flow of the roundabout within the smaller cars and trucks between the critical gap has become larger, so that traffic flow in the roundabout in small, around the roundabout and external flow around the larger.

2 Roundabout Design

- Multi-lane Road is more conducive to improve the traffic capacity than single-lane Road Roundabout, design the number of lanes in Roundabout, people generally center roundabout as a bypass lane, the most outside one, as a right turn lane, Central lane for vehicles intertwined use of motor vehicles Road, lanes more than four, very little increase in traffic capacity, it will cause traffic chaos that is not conducive to safety. Therefore, the Central Road Vehicle Road is generally 2 to 4.
- Traffic flow through the roundabout and the traffic capacity of factor analysis, the radius of a very roundabout, roundabout traffic flow within the large roundabout with traffic capacity, and that is to narrow the traffic circle center radius can improve capacity. Roundabout traffic circle diameter of the ring down to cross the outer edge of the inscribed circle diameter of about one-third, while export-oriented bias Settings Island, in order to import lanes widened.
- Entering the import of "parking" signs or "given" signs, to have the vehicles entering the roundabout traffic priority, making traffic flow within the traffic circle is not too big and cause traffic congestion.
- At the entrance of the roundabout, to increase vehicle lane be a few, making the car have more opportunities to enter the roundabout.

4.3 Case 2: Traffic Light Control

4.3.1 Our Approach to the Roundabouts with Traffic-lights

For large-scale roundabout, traffic will usually big, so measures must be taken to carry out the reasonable control of traffic flow, and the installation of traffic lights is an effective method, and many roundabout have set up traffic lights, so our program 2 will discuss and optimize large roundabout with traffic lights and traffic lights ratio of green time.

Many experts and scholars at home and abroad have already conducted the study of the large-scale roundabout, under the effective control of traffic, hoping to make rational use of large-scale roundabout to ease traffic pressure, improve the operational capacity of the roundabout and to reduce congestion, with the help of the traffic lights. One of the sophisticated theory is the "Turn Left Quadratic Control" theory, which is proposed by Professor Yang Xiaoguang, Tongji University. This control method is a organic combination of the time and space resources and it can avoid all the traffic flow going mixed, so it can have an orderly, coordinated operation, greatly improving the capacity of the roundabout. This method has attracted extensive international and domestic attention since the publication [8] [9]

However, the prevalence major issues are as follows: If the signal control method of intersection is the symmetric distribution, it can't adjust the control program on the base of the asymmetry between the internal flow at the same time of the two relative approach. The green light Time of the signal cycle has not been fully utilized, and time and space resources cannot give full play to the detriment of its capacity. Now we will conduct further studies of the theory to improve the applicability of the theoretical and practical value.

4.3.2 The Improvement of the Reasonable Roundabout Design

1. Roundabout Space Design

(1) lane layout

According to characteristics of inflow traffic demand (volume and flow) and the conditions of the space, taking into account the flow of the large-scale roundabout will be very big, so entrance road shall be divided Road turn left, go straight, right turn lanes; Ring Road shall be divided into left turn, straight

special lane. As shown in Figure 6.

(2) Stop line Design

In order to realize two-step control of the left turn traffic flow, Stop line must be set in entrance road and ring road to ensure an orderly flow of traffic. As there is reaction time T0 and vehicle acceleration time Ta when drivers see the green light, the two time have both become the initial loss of green light time Tin order to minimize loss time of the green light as much as possible, we can set the stop line at some distance L from the entrance to enable them to travel at full speed.

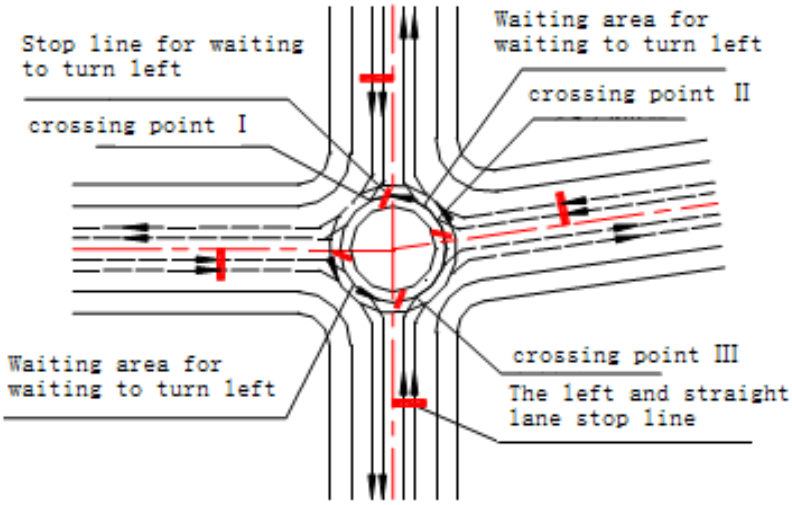


Figure 6 The special roundabout

(3) signal light configuration

In order to best coordinate and control turn-left, go-straight of the entrance road and the turn-left traffic flow of the ring road, the signal with control function and corresponding signal lights need to be configured : in the first stop line before the vehicles visual position 4 signal lights should be set to control the left and straight flow of entrance road; in the second stop line before the vehicle visual position 4 signal light should be set to control the turn-left traffic flow on the ring road. As shown in Figure7

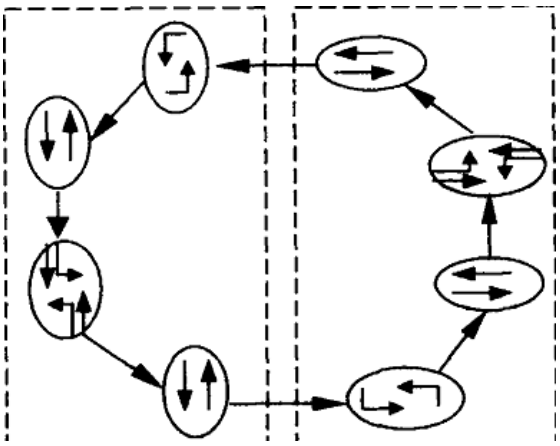


Fig.7 Singal phase sequence of roundabout

2. Phase Analysis

Four large-scale cross-Ring, as a result of enough space conditions of the ring road, in the entrance road, the two-phase control should be adopted, while in the ring road, the corresponding

two-phase control. Specific phase convergence, as well as the combination of the internal phase between is shown in Figure 7 [10] .

3. The determination of green light control tine

Urban traffic lights control commonly adopted fixed-time interval converter control method, which fixed the same traffic signal timing control between north-south and east-west green light delay time. Because the car numbers in all directions around the roundabout are not balanced, and Traffic is not the same as the time, therefore, To determine the time interval of urban green traffic lights green is essential for improving the roundabout traffic. In order to change this defect, we use the fuzzy control theory and design a fuzzy controller to calculate the time interval of the green light in order to achieve accurate calculation of green traffic signal light delay time on the cross-road.

traffic lights signal delay control program analysis

Due to different circumstances and traffic situation may have great differences, thereby increasing the difficulty of the green light delay time control. Usually in determining the delay distribution of traffic lights in the intersection, the delay time of the vehicle through the intersection will be the only measure, and then the time distribution will be optimized. However, the classic formula for calculating the time delay is not always accurate around the roundabout for the complex situation, especially during heavy traffic. Fuzzy logic model has the advantages of no need of access to the complex relationship and identify accurate model, so it can be used to transport variable or non-linear relationship between the complexity of the description of function.

In this paper, we control the delay time by considering stranded queue number during the red light and the number of passed vehicles during the green light .we want to make proper fuzzy control rules to construct a fuzzy controller, which can be used to decide the distribution of delay time .Figure 8 shows the intersection traffic lights with delay control block diagram.

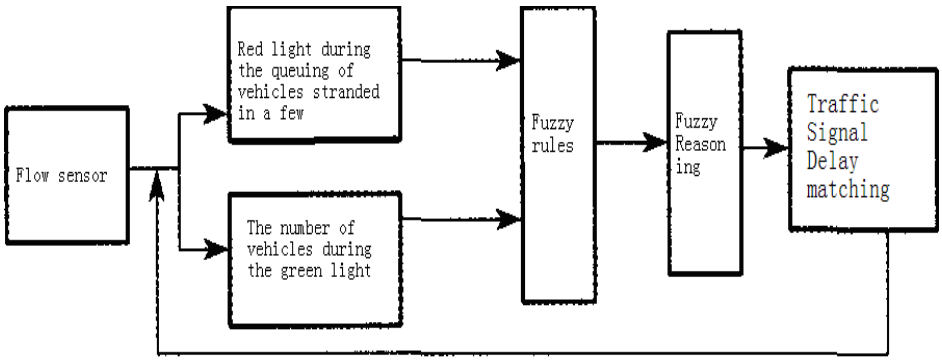


Figure 8 Sketch of control system for the delay time of traffic lights

The design of the fuzzy controller to decide the delay time Steps as follows :

Step 1: Undertake a systematic analysis of input variables, output variables and controller structure to determine the fuzzy controller ,

Step 2: Give the definition of input and output variables and membership function domain, the establishment of control rules and determine the operator to choose the anti-fuzzy method

Step 3: Simulations can be carried out off-line simulation can also be online in real-time measurement; the method to do off-line simulation first, then online real-time measurement is recommended.

MATLAB fuzzy controller design steps and the specific steps detailed in reference [11]

Use multi-input single-output type to design the control rules of fuzzy controller that is,

If E1 and E2 and⋯ and En Then U (10)

Minimum fuzzy implication operator (Mandeni), and synthesis using fuzzy max In regard to the traffic light signal delay of the output of fuzzy controller fuzzy decision information, the use of the largest membership degree method, that is, when

$$\mu U'(\mu_{max}) \geq \mu U'(\mu) \quad (11)$$

Check the output of fuzzy control the amount of the membership degree u corresponding to the maximum amount of elements as part of the implementation. If u, showing two peaks or peaks, that is,

$\mu_{max\,1} \leq \mu_{max\,2} \leq \cdots \leq \mu_{max\ell}$

Then we choose the average amount. that is

$$\overline{\mu} = \sum_{i=1}^{\ell} \mu_{maxi} / \ell \quad (12)$$

We adopted the fuzzy rules in the following table which has been studied by the relevant experts [13]。

Table 1 Fuzzy rule table

q_n / q_{n+1}	VS	S	M	B	VB
VS	VS	S	L	VL	VL
S	VS	S	M	L	VL
M	VS	VS	S	L	VL
B	VS	VS	S	M	L
VB	VB	VS	VS	M	M

4.3.3 Case Summary

We design the proper space of the roundabout by using the 'Second and Left–Turing 'method ,then under the control of traffic lights, road vehicles on the island get a reasonable time for the optimal allocation of different traffic flow and make timely adjustments to meet the time and space resources.

4.3.4 A Special Case Study

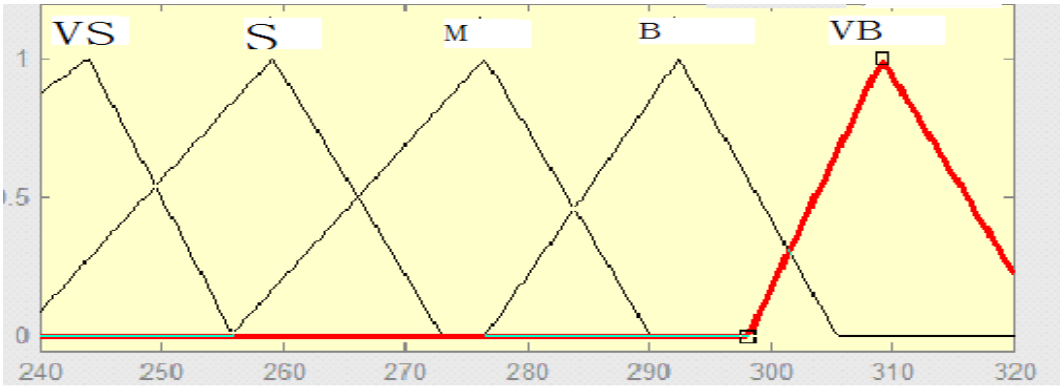
According to a roundabout in a certain region one day's traffic changeable flow, We can get the different allocation of green time in different number of traffic flows by using the method mentioned above.

Assuming the day number of vehicles stranded in front of the line during the red time 300 and has a relatively concentrated, and generally can be divided into 5, the number of vehicles during the green light to do deal with, the list is as follows

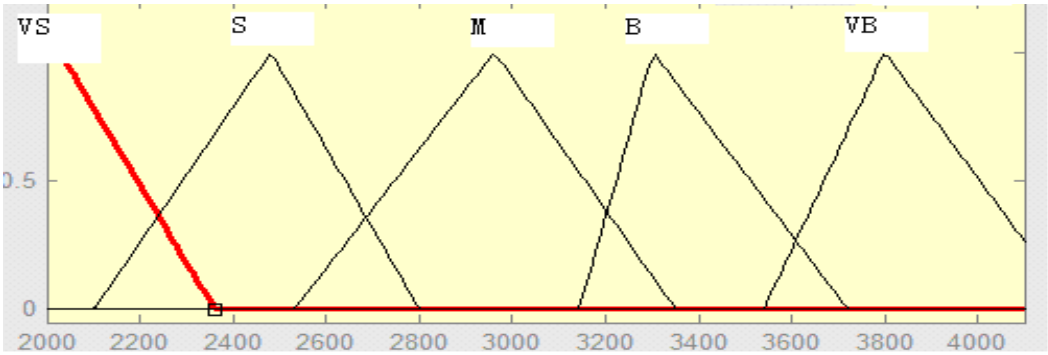
Table 2 the number of vehicles during the green light

Day time period	The number of waiting vehicle	Number of the vehicles during Red light	Fuzzy quantity
00：00～6：00	≤250	≤2800	VS
20：00～22：00	250～280	2800～3500	S
7：00～9：00	280～300	3500～4000	M
11：00～12：00	300～305	4000～4100	B
16：00～18：00	>310	>4100	VB

Fuzzy controller for the input, output membership function distribution of membership functions of Figure 9



Red light during the queuing of vehicles stranded in the number



Green light duration membership function graph

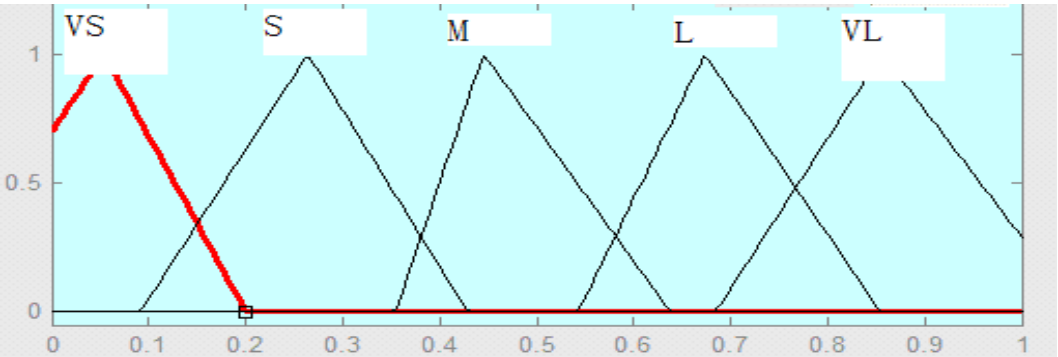


Fig . 9 The distribution of membership function on rush hours

Figure 10 for the traffic signal at fixed delay time 2 min outside the 60 S period of time, according to Fuzzy rule table in Table 1, use MATLAB software by the fuzzy inference output when the time of the green light surface .

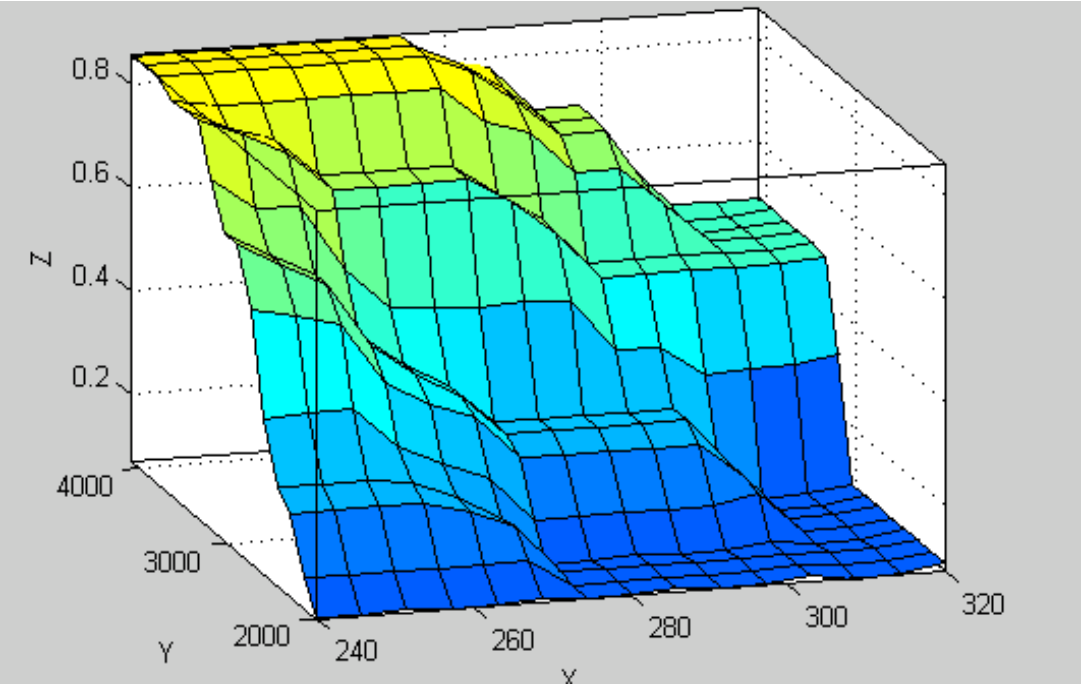
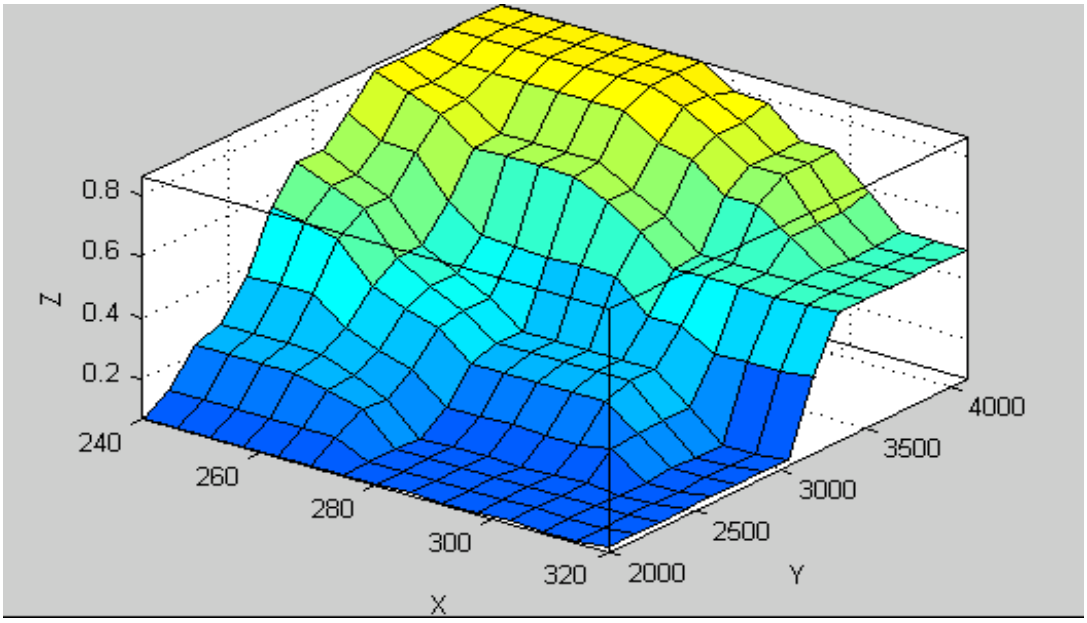


Figure 10 the traffic signal at fixed delay time 2 min outside the 60 S period of time

X: Red light during the queuing of vehicles stranded in a few

Y: The number of vehicles during the green light

Z: Time length of the green light



This is from two different point of view of stereogram , the level of map space left superscript X (units of vehicles), on behalf of Red light during the queuing of vehicles stranded in a few ； space vertical coordinates Y (units of vehicles), on behalf of The number of vehicles during the green light ； and vertical space coordinates Z (units of minutes) on behalf of Time of the green light.

Model applications: for the day roundabout actual traffic situation, the following can be a distribution of time of the green light table

Table 3 Distribution of time of the green light

Day time period	Time of the green（S）
00：00～6：00	20
20：00～22：00	25
7：00～9：00	45
11：00～12：00	40
17：00～18：00	30

With this in mind, so check 00:00 ~ 6:00 this period when the l time of the green light for the 20s; at 20:00 ~ 22:00 ,7:00 ~ 9:00, and at these times due to the passage of vehicles during the green light more than a few changes, so a long stretch when the green light; but in 11:00 ~ 12:00 and 17:00 to 18:00 as a result of this stranded vehicles queuing at a red light a few relatively large,

although the green light at this time period the number of vehicles to get through a big change, but is still a long stretch when the green light to those who will be lining up to wait for too long, so the green light instead reduced the length of time. This shows that the fuzzy control in line with the actual, practical.

Model Summary:

The method using fuzzy control structure, and avoid the traffic system as a result of the uncertainty arising from variability timely control rules complex issue. With the traditional fixed-delay systems can shorten the average delay time for vehicles, but also demonstrated the advanced nature of this method and the feasibility of the practical application of the method of laying a theoretical foundation, and its accuracy and the advantages of intelligent control Traffic more complicated when the status quo can be fully reflected.

4.4 Case 3:The Association of the Model

4.4.1 The Background of the Dynamic Lane Management:

In reality, the “Tide Phenomenon” ,the proportion of which is as high as 20% -40%, is widespread in the traffic of Urban Road Network. [12] This phenomenon will often lead to uneven use of resources around the island lane. More seriously, it will cause one side overcrowded, while the other side empty. To alleviate this situation, we can be applied to dynamic lane management techniques. [13] which is based on the characteristics of the traffic demand changes. With this new technology, the function of the road lanes and lanes around the island can be adjusted dynamically to adapt to changes in traffic flow.

The achievement of dynamic lane management techniques is mainly divided into three categories: Firstly, the dynamic management of the direction of the lane section; Secondly, the dynamic management of the function of intersection approach; thirdly, the dynamic management of lane objects, such as the dynamic switching of the motor vehicle road and non-motorized road. Although these three management ways are different, but their essence is, for the conditions of the uneven distribution of traffic flow, to improve the utilization of transport facilities as much as possible. For example the circular cross road, changes in flow distribution are more

complicated than the road, which can dynamically divide the lane function to realize combinatorial optimization of time and space resources. For a single signal control intersections, combined with the signal phase set, the optimization model of the lane function set are discussed as follows.

4.4.2 Objective Optimization

The optimize target of lane function and signal phase combination model is to minimize the total intersection flow ratio Y . The total Intersection flow ratio Y is the sum of the biggest signal phase traffic flow ratio yi, it is usually regarded as constants, which reflect the actual demand for the passage. And the green signal ratio λ is regarded as a controllable parameter, which is a representative of available capacity [14] . In this sense, the optimization of signal control is a means to improve traffic supply, however, lanes function in dynamic optimization is a means to reduce the "demand".

the following formula is the objective function:

$$\min Y = \sum_{i=1}^{T} yi \qquad (13)$$

4.4.3 Constraint Condition

For the lane function distribution, the main constraint are the following three conditions:

1. Lane number constraint: the number of approach lane is equal to that of out lane.

2. Combined lane constraint: The approach lane of each combination is less than 1, some lanes of conflict should not exist. [15]

3. Lane matching constraint: When the traffic flow is going through the circular intersection from the approach lane, the number of out lane should be no less than the approach lane traffic flows.

For the phase selection, the main constraints are the following two conditions:

1. Combined lanes synchronous constraint: The different traffic flow of the same combined lane should always be released simultaneously.

2. Conflict traffic flow constraint: In order to meet the safety and efficiency requirements of the intersection, it should ensure that the conflict traffic flow is not allowed in the same phase.

4.4.4 Summary:

This optimization method is flexible, adaptable, and can be applied to the complex lane around the island, which is a good way to use road resources. It will be a research direction to alleviate the traffic pressure of the complexity of the road around the island.

5 Technical Summry

Traffic circle plays an important role in today's transport circle. The rational design of the roundabout is important to alleviate the increasingly serious traffic pressure. Our goal is to build a model program to make the best choice to control traffic flow around the roundabout.

Through the analysis of traffic flow we get different application program out of the number of the traffic flows. If the number of traffic flow is within a certain critical value it implies that we can design a round without traffic lights, in the contrary, we should take measures to control the traffic flow, setting a traffic light is such an approach.

Case one:

1) In the small traffic circle, we should provide priority to the cars which are waiting for departure through the allowance signs.
2) When the traffic flow is less, we can device the single-lane, and achieve flow control through widening the width of the lane.
3) When the traffic flow approaches the critical value, we can increase the number of lanes to give the exact vehicles with the same direction the same lane. It is worth noting that the number of the lanes can’t be more than 4, otherwise it will cause traffic chaos against the purpose.
4) Reducing the radius of the center can improve the traffic capacity. It will get the best result if we reduce the diameter of the traffic circle to

about course the diameter of one-third of the outer edge of the ring cross inscribed circle.

Case two :Using the traffic lights to control traffic flow

1) We should make good use of "Second- left Turning Control Method" to optimize the space around the island, and make the separated lanes for the exact vehicles.
2) The rational settings of the green light time play an important role in controlling the traffic flow. So we apply the Fuzzy Control Theory to set the fuzzy controller for traffic lights. It can give the proper time length based on the number of the traffic flows in reality.
3) If there exist a situation when the traffic flows distributed very imbalance ,we can implying the Dynamic Lane Approach theory .it will ease and optimize the traffic flow through timely adjustments of the function of the lanes.
4) If we meet some extreme condition, we can set the weight factor to decide which measure or measures should be taken.

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