Research on the Mechanism of Multi-resource Mapping Matching and Transmission of Road System Based on Meme Theory

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Abstract. Because of the inefficiency and unscientific use of existing urban road traffic facilities, this paper sorts out the problems and optimization methods of domestic and foreign road traffic system, establishes the "set of problems" and "set of countermeasures". Put forward the replication factor and mutation factor of optimization methods based on Meme theory, carry out the matching and transmission of multiple resource mapping, and feedback the implementation effect of the plan through simulation application and evaluation, so as to improve the mechanism of multi-resource mapping matching and transmission model. Cases study proved that Meme theory can be better applied to the automatic matching and selection of urban road traffic system optimization schemes and guided the optimization of urban road traffic systems more efficiently.

1. Introduction
The concept of Meme was proposed by Richard Dawkins, the advocate of Neo-Darwinism, in the book “Science Fiction” [1]. It refers to the thoughts or ideas that are imitated and spread among people in the cultural field [2]. Foreign memetics originated from biology and then entered the fields of social science, for example, Lynch A used memetics to study the cultural evolution of the populations of common chaffinches in the Atlantic Islands in 1994[3]; Jill et al. proposed an experience-based memetic identification method[4]. In China, however, it originated from linguistics and then entered other fields. Yang Liuxiang et al, analyzed the five types and functions of fan network words from the perspective of memetics [5]; Hou Guojin discussed the replication and transmission of memes with similarities and differences, especially pragmatic memes[6]; In terms of transportation, the application of Meme Theory mainly focuses on path selection. Such as dynamic vehicle routing algorithm[7], finite capacity arc path problem[8], and traffic state discrimination[9]. In these applications, Meme Theory can better overcome the disadvantages of low reliability. In a word, Meme Theory has been widely spread in biology, culture, ecology, physics, language teaching and other fields because of its strong expansibility, high search efficiency and strong fault-tolerance.

Drawing on the experience of Meme Theory in these fields, this paper sorts out the problems and optimization methods of road traffic systems at domestic and foreign, and establishes a road traffic system "set of problems" and "set of countermeasures" respectively. Using Meme theory to match and transfer multiple resources, through simulation application and evaluation, feedback the implementation effect of the plan, so as to guide the optimization and construction of transportation facilities more efficiently, and also save a lot of time, energy, and cost.
2. Meme Matching Technology of Multi-resource Mapping Road System

2.1 The Structural Analysis of "Set of Problems" and "Set of Countermeasures"

For the structural analysis of the "set of problems", this paper mainly studies road sections and intersections. Generally, affecting the capacity of urban roads and intersections are divided into road conditions, traffic conditions, control conditions and environmental conditions [10]. The road conditions mainly include the number of lanes, geometric width (lane-width, non-motor lane width, side walk width, central reserve width) and design speed; traffic conditions mainly include traffic volume (traffic flow, non-motor vehicle flow, saturated flow); control conditions mainly include signal timing, signal period, phase difference, green ratio; environmental conditions mainly include weather conditions and visibility.

The corresponding situations of different road sections and intersections are generally similar, but there are differences in some details. Road section has the attribute of traffic facilities, it includes the influence parameters of location, highway type, pavement condition (road surface condition, pavement material, slope). In addition, the control conditions are not included because of no signal on the road sections. The geometric structure of the intersection is more complex than the road section, so the following parameters are also included: the number of rings, the length of weaving section, the distance between intersections, the queue length of vehicles.

For the "set of countermeasures", the optimization methods of traffic system control are mainly sorted out from the vertical (planning, design, construction, operation management control) and the horizontal (road hardware facilities and surrounding facilities), and corresponding roads and intersections database is established. Considering the possibility of effective matching of Meme Theory, similar cases can be classified into one category.

2.2 The Matching Process of Road Traffic System Based on Meme

The matching process of road traffic system based on meme is as follows:

(1). Numbering: perform data analysis on selected targets. Different parameters of road sections and intersections correspond to different numbers.

(2). Selection: in meme algorithm, roulette is used to randomly select individuals to generate a mating pool of size n. The maximum and minimum method is used to ensure that the extremum solution in the Pareto front end is preserved in the selection.

(3). Crossover: the selected parent must pass through a special single point crossover. The probability of crossover is set in advance, and two children are generated after crossing.

(4). Variation [1]: variation is a random change of the elements of a gene based on the probability of variation. The mutation probability is a dynamic probability.

(5). Search: using the reference data of road intersection, one or several suitable schemes can be found out from many technical methods in the set of countermeasures.

(6). Matching: when one or more schemes with the same or similar conditions are searched, these cases can be used as a reference for the optimization approach.

(7). Feedback: for the improved intersections and roads, there will be a series of changes, such as queue length, average delay, time occupancy and other data, which can be obtained through the feedback mechanism.

(8). Re selection: compare the data obtained before and after, and make a reasonable analysis, if the traffic condition after the application of the optimized scheme is still in the state of congestion, then the matching scheme will be selected again in the set of countermeasures.

(9). Inheritance: when the problematic road section is like to the known basic road section, the known basic road section can be copied as a meme.

(10). Termination condition: when the improved intersection reaches the point where its traffic problem has been solved or its data can approach the case data in the scheme, that is, it can be considered as a new case, the intersection can be terminated. In this case, a new meme is formed, and the set of countermeasures database can be effectively updated.
3. Optimization Feedback and Delivery Mechanism of Road Traffic System Based on Meme

3.1 Road Traffic System Information Feedback Technology

Not all coupled combinations will be fully applicable after the matching is completed. Therefore, a corresponding feedback mechanism should be set behind the system to timely find out the problems and take corresponding countermeasures to solve them.

Feedback information: Bai Hua et al. [11] analyzed point-level and line-level evaluations based on factors such as class saturation, queue length, average delay, and time occupancy. This paper draws on the research results, and at the same time, it also needs to have more detailed records and descriptions for special circumstances, such as the unexpected accidents that may occur in some road sections.

Through the real-time monitoring of the road, the data and images on the road are acquired, and then transmitted to the data analysis system for analysis and evaluation. After image processing, class saturation, queue length, average delay, time occupancy and other related data are fully displayed on the electronic map. These data can be compared before and after the improvement, thus judge the correctness and effectiveness of the improvement scheme and make a brief evaluation of the scheme. In addition, the strength and assimilation ability of the meme can be obtained, which can be used as the main basis for future replication and application in other places.

3.2 Optimization of Road Traffic System Matching Process Based on Meme

The effective solutions in the countermeasure group are used as memes, copied, and applied to the problems that need to be solved. After the validity of memes is proved, correct analysis and state discrimination can be carried out on memes through information feedback mechanism. When traffic problems at intersections or road sections are solved or effectively optimized, assimilation memes will generate a positive sense of belonging and release their assimilation ability. If the two are matched, the meme will be spread and applied effectively; On the contrary, if the road section or intersection does not develop to the planned road, dissimilation memes will be generated to reflect the mismatch between the two, and new memes need to be selected.

In this paper, roulette or competition mode is used for re-selection. Different strong memes have different priorities, give priority to more powerful memes to get a new set of matched coupling models with less time and cost. After feedback simulation for many times, the most suitable method to solve this problem can be obtained, which can greatly save the cost of time, manpower, material resources, financial resources and so on, and at the same time make the urban transportation system effectively optimized.

3.3 Determination of Key Index Threshold of Road Traffic System Optimization Method Based on Meme

A, B, C and other schemes are obtained through scheme matching, and then these schemes are evaluated and scored, and the recommended scheme with the highest score is selected for users to choose, so as to optimize the intersections. The scheme is evaluated by the parameters of feedback information.

In order to comprehensively evaluate the optimization scheme of roads and intersections, this paper is not limited to one index, but selects three indexes of class saturation, queue length and average delay to comprehensively evaluate the optimization scheme of intersections, and selects two evaluation indexes of saturation and occupancy to comprehensively evaluate the optimization scheme of road sections. The hierarchical evaluation scope of these indicators can be referred to [11]. Table 1 is obtained after standardized treatment of evaluation thresholds of each indicator.
Table 1. Standardization of evaluation index threshold

| Evaluation Object | Evaluation Indicator  | $Y_{ij}$ | $Y_{ij}$ | $Y_{ij}$ | $Y_{ij}$ |
|-------------------|-----------------------|----------|----------|----------|----------|
| Intersection      | Class Saturation      | 0.400    | 0.550    | 0.700    | 0.900    |
|                   | Queue Length          | 0.064    | 0.157    | 0.191    | 0.277    |
|                   | Average Delay         | 0.043    | 0.184    | 0.261    | 0.478    |
| Basic Sections    | Road Saturation       | 0.300    | 0.600    | 0.700    | 0.800    |
|                   | Occupancy Rate        | 0.150    | 0.250    | 0.500    | 0.750    |

$$R = \sum_{j=1}^{n}(Y_j)^2$$

In the formula, $R$ is the traffic comprehensive operation index; $Y_j$ is the index value of the $J$th item in the index set, $j=1,2,\ldots,n$, and $n$ is the number of indexes. The variable $Y_{ij}$ is substituted into formula (1) for analysis to obtain the classification threshold of traffic comprehensive operation index as shown in the following table.

Table 2. Threshold values of comprehensive evaluation indexes

| Evaluation index threshold | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|---------------------------|-------|-------|-------|-------|
| Intersection              | 0.166 | 0.361 | 0.595 | 1.115 |
| Basic Sections            | 0.113 | 0.423 | 0.740 | 1.203 |

Traffic operation state can be divided into five grades: $0 < R \leq R_1$ is unimpeded, $R_1 < R \leq R_2$ is basically unimpeded, $R_2 < R \leq R_3$ is mild congestion, $R_3 < R \leq R_4$ is moderate congestion, $R > R_4$ is heavily congestion.

4. Case Analysis
In this paper, the virtual calculation method is used for analysis. Now it is assumed that the data of a roundabout are surveyed. The layout of the roundabout is shown in Figure 1.

![Figure 1. Roundabout layout](image)

Table 3. Survey data of roundabout

| Evaluation Object | Class Saturation | Queue Length (m) | Average Delay (s) |
|-------------------|------------------|------------------|-------------------|
| Intersection      | 0.52             | 59               | 47                |
The survey data of roundabout evaluation unit are shown in Table 3. After standardized processing of survey data, the formula (1) is substituted into Table 2, and the evaluation results of the roundabout are shown in Table 4.

The traffic operation status is judged as mild congestion, it indicates that the roundabout needs to be optimized and improved. After searching in the set of countermeasures, two schemes of transform the intersection into a conventional intersection and an induction signal intersection are provided, thus obtain the mapping of multi-resource.

Table 4. Evaluation results of roundabout

| Evaluation index | Evaluation value | Evaluation result |
|------------------|------------------|-------------------|
| Roundabout       | 0.50             | Mild congestion   |

Table 5. Evaluation index data of the two reconstruction schemes

| Evaluation Object          | Class Saturation | Queue Length(m) | Average Delay(s) |
|----------------------------|------------------|-----------------|------------------|
| Conventional intersections | 0.39             | 49              | 33               |
| Induction signal intersection | 0.32            | 45              | 11               |

Table 6. Evaluation results of the two reconstruction schemes

| Evaluation index             | Evaluation value | Evaluation result   |
|------------------------------|------------------|---------------------|
| Conventional intersections   | 0.23             | Basically unimpeded |
| Induction signal intersection | 0.12             | Unimpeded           |

VISSIM simulation is carried out on the reconstructed conventional intersection and the induction signal intersection. The respective survey data and evaluation results of the two schemes are shown in Table 5-6:

It can be seen from Table 6 that the final traffic status of the two schemes are basically unimpeded and unimpeded respectively, so both schemes can be selected. However, the roundabout will be transformed into the induction signal intersection after the optimal selection, as shown in Figure 2. In addition, data feedback should be provided after the completion of optimization, thus see the effect of optimization and the practicability of the scheme. Meanwhile, a data update should be made to the set of countermeasures.

5. Conclusion
This paper constructs the "set of problems" and "set of countermeasures" of the road traffic system, and conducts coupling matching based on the Meme Theory, and establishes the meme delivery mechanism of efficient traffic system optimization to alleviate various traffic problems such as urban traffic congestion. In the case, based on the corresponding survey data, the dynamic comprehensive evaluation method is adopted to obtain the traffic status of the corresponding evaluation objects. After the traffic system optimization based on memes, traffic congestion at roundabouts has been greatly improved.

Based on Meme Theory, this paper conducts coupling matching between "set of problems" and "set of countermeasures", mainly aiming at traffic system optimization of intersections and roads under
normal conditions. In the next step, consider the applicability of the mechanism in emergency situations.

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7. References
[1] Dawkins, R 1976 The Selfish Gene (New York: Oxford University Press)
[2] Dawkins, R 1982 The Extended Phenotype (New York: Oxford University Press)
[3] Lynch A and Baker A J 1994 A population memetics approach to cultural evolution in chaffinch song: differentiation among populations. Evolution. 48(2) pp 351-9
[4] Jill, Shepherd B, McKelvey 2009 An empirical investigation of organizational memetic variation [J]. J Bioeconomics
[5] Yu-Lei D and Shu-Hua W 2010 Analysis of cyber manhunt from the perspective of social psychology [J]. J Kai'feng Univ
[6] Guo-Jin H 2008 Meta-pragmatic awareness of meme hosts and meme variation [J]. J Sichuan International Studies Univ, 04 pp 50-8
[7] Ying P and Jiaqi C 2015 Research on dynamic vehicle routing algorithm based on multi-agent simulation [J]. IT, 5(1) pp 121-4
[8] Ting-ting Y 2006 Research on arc path problem of finite capacity based on meme evolution algorithm [D]. J Beijing Jiaotong Univ
[9] Qi-Chun B, Bowen G, Zhao-Sheng Y, 2015 Traffic state identification for urban expressway based on projection pursuit dynamic cluster model[J]. J Southwest Jiaotong Univ, 12(1) pp 1164-9
[10] Jia-Jie L and Yi Z 2006 Analysis of factors influencing on traffic capacity of urban road. Urban Roads Bridges & Flood Control, 03 pp 5+36-38
[11] Hua B, Jian-Jun W, Yi-Mei J 2018 Evaluation of traffic operation state of highway network based on point, line and area level. China J. Highw Transp, 11 pp 201-8