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Intelligent Transport System Based on Genetic Algorithm

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Abstract: these work proposed a method for controlling traffic lights in order to have maximum flow in the route which result in a moving traffic. As decision is making based on stochastic data, the method improve the decision in practice. In long term the estimation approaches the real situation in each area, which this algorithm is used. In our method sensors send information on a computer, then based on genetic algorithm timing of green in traffic light is adjusted. Simulation result based on real data shows the full capacity of cross and route is reached.

Key words: Genetic algorithm . stochastic system . transport system

INTRODUCTION

The goal of Intelligent Transport Systems (ITS) is applying information technology, communications, sensor technology and the internet to transportation systems to improve travel safety, reliability, passenger convenience, increase mobility, mitigate traffic congestion and reducing fuel consumption. Intelligent traffic control system is an important part of the ITS [1].

There is a great potential in ITS to improve existing transportation Systems. As the scientific reports show the concept of ITS return to the 1970s, but after the first ITS world congress in Paris in 1994, many nations only started to apply intelligent transport systems to develop and improve the existing traffic control systems. The industrial countries have started use of car navigation systems and traffic information services on a large scale. Successful implementation of the vehicle information and communication system makes Japans the only country with the most advanced intelligent transport systems in actual operation in the world [2].

Continues efforts in order to promoting intelligent transport systems for solving transport problems have greatly accelerated the application of the ITS. Simultaneously, the recent progresses in the information technologies has also speed up the deployment of intelligent transport systems. More complexity in the intelligent systems than traditional transport systems achieved by using the information technology. The rapid development of the ITS has led to an urgent need for a corresponding evaluation frameworks to tackle not only the social and economical impacts of deploying intelligent transport systems but also the environmental impact. There is no enough capacity in traditional evaluation methods to deal with some recent developed features in intelligent transport systems, such as the impact of ITS on personal travel and commercial transport, the dynamic nature of the ITS, the adoption of new information technologies, especially the long-term impacts of ITS are not well addressed in the previous studies. Different research fields of intelligent transport systems guarantee the future of transportation systems and will eventually create a new industry sector with its implementation. The benefits and costs from intelligent transport systems are examined from various aspects through the whole lifecycle of the ITS infrastructures and variant user behaviors due to the implementation of information. Reviewing efforts of researches provide a complex decision-making framework to provide decision makers and the public with a better understanding of the benefits of implementation of intelligent transport systems. Cost-benefit analysis and multi-criteria analysis is a base for most evaluation frameworks, which are available to date [3].

Although intelligent transport systems are a part of transportation infrastructure systems, traditional methods can be used to evaluate these systems. The traditional methods are too general in a number of aspects to be used in the evaluation of intelligent transport systems. ITS are information technology oriented, but the existing methods do not include such modules which are needed to analyzing the growing impact of information technology in this field. They are

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offer drivers a wide range of information on the performance of the transport system, which has a great influence on the user behavior, the existing evaluation framework, which is mainly based on cost-benefit analysis. It is not suited to analyzing the changes in user behavior. ITS are dynamic and interact with different agents, such as traffic information centre and vehicle users. This is a big different with the traditional transport systems. In addition, ITS are market-driven compared with the other infrastructure systems. The government still plays a key role in building ITS infrastructure, such as traffic information and control centers. The public understanding the benefits of the ITS and being involved in their planning, which has seldom been considered in the past under the previous evaluation framework, guarantee the successful implementation of ITS project.

In developed countries cost-benefit analysis is still the dominant method for evaluating transportation projects despite its limitations [3,4]. In general, cost-benefit analysis or its variants is a guide in ranking the viability of projects. The framework of the methods are consist of the following parts: transportation demand forecast, traffic safety, value of time, regional economic impacts, environmental impacts, efficiency criteria, financial analysis and post evaluation. Practically, For transportation demand forecasting conventional stepwise method is widely used, which leads to inconsistencies in the steps, but there are several alternative methods for utilizing dynamic traffic assignment and simulation in considering the effects of congestions. Dynamics traffic assignments have been intensively studied in previous research [5].

Q. Chen and his collogues, have been presented how to evaluate the global traffic effect of a telemetric route guidance system by using a developed simulation [6]. A modeling framework was proposed for analyzing the impact of transport measures in terms of network energy consumption and pollutant emission [7]. Commercial transportation planning software and traffic simulation software is used to get network flow, speed and travel time. For evaluating the impacts resulting from transportation projects with a specific orientation to environmental impacts, which combines multiple-criteria analysis and cost-benefit analysis methods, a generalized methodological framework was developed [8].

In Australia, a decision support system was developed to assist planner, regulators, transport operators and consultants to predict the impact of transport strategies. It has capability of making recommendations based on the predictions [9].

Based on cost-benefit analysis in transport infrastructure, the intelligent transport systems benefit priorities were investigated, which identify what kind of costs and benefits should be included in the cost-benefit analysis [10].

ITS are complex systems. It is important to find out what should be included or excluded in the evaluation system. This part is to establish the inputs and outputs of evaluation model and identifying the benefits and costs related to the implementation of ITS infrastructure. The ITS implementation may generate several effects, such as engineering economics, transportation network performance, improvement of safety, environmental impact, regional economic impact and efficiency and equity considerations. This module aims to develop a group of factors for evaluating new intelligent transport systems and develop performance indicators, which give a measure of the effects on society, economics and environment. Both short-term and long-term impacts of ITS implementation are analyzed based on those factors.

Due to the short history of ITS, relatively little is known about the long-term impacts intelligent transport systems. Dynamics method in the evaluation model will be solved this issue. The requirement of first part of the model is straightforward. The parameters related to network performance are: travel time, traffic flow distribution, journey distance and speed. The travel time saved by implementation of ITS. Two type of time will be involved as working and non-working time. The improvement in convenience such as accessibility achieved through the implementation of ITS is also included in the model. The cost of accidents is main index of traffic safety. It is expected that the ITS implementation reduce accidents. The measure of this improvement will be included into the framework. The environmental impacts mainly focus on two aspects as air and noise pollution. They are obtained through an emission model, which provides the amount of pollutants and a dynamic traffic simulation model, which provide the flow distribution, queue length, time and location. Another major indexes of the evaluation framework are direct and indirect impact on the environment, such as establishing of new industries by the implementation of the ITS projects. Efficiency and equity of the ITS project are an important issue not only for governments and decision makers, but also for the public.

Since the late 1980 geographic information systems (GIS) have been widely used in transportation research and management, especially as GIS-transportation (GIS-T) data models were developed for sharing of data between GIS and transportation systems [11,12]. Geographic information systems are also used for travel demand models [13].

C.A. Quiroga and his colleague proposed an integrated methodology combining both global positioning system and geographic information systems technologies to perform travel time studies [14].

The aim of this research is to proposed a method for controlling traffic lights in order to have best mobility in a route.

PROBLEM FORMULATION

As in the trafic analysis the human behaviour is the main object and it is mixed by uncertenty, we use stochastic system for analysing the trafic. In this work it is asumed there is four trafic lights in each junction. There is a number assigne to each one as shwon in Fig. 1. The numbers are even or odd. The state of the junction is coded as follow: If the even lights in a juction are green the code is 1 and if the odd lights in a juction are green the code is 0. This means we have binary code for the state of each junction. It means each junction has two states. In other word for n junction in a route there are 2^n situations. In order to reducing the mutually dependance between junctions we approach an optimum alghorithm. As we use binary code, the genetic algorithm [15] is used in this work. Figure 3 shows the flow chart of the method.

Based on trafic center information the mean μ and standard deviation σ of flow trafic in each juntion is determined. By using cumulants which express by following formula:

$$k_1 = m_1 \qquad \text{(1-A)}$$

and

$$K_t = m_t - \sum_{i=1}^{j-1} \binom{j-1}{i} k_{j-i} m_i \qquad j \geq 2 \qquad \text{(1-B)}$$

In which

$$m_1 = k_1 \qquad \text{(2-A)}$$

and

$$m_t = k_t - \sum_{i=1}^{j-1} \binom{j-1}{i} k_{j-i} m_i \qquad j \geq 2 \qquad \text{(2-B)}$$

Based on above parameter Gram-Charleir expansion[16] is used to calculate pdf of each juncton by following formula:

$$k_{t_{sn}} = k_{t_{ii}} + \sum_{i=1}^{p} k_{t_{ij}} + \sum_{i=1}^{p} k_{t_{start}} - \sum_{i=1}^{p} k_{t_{stop}} \qquad (3)$$

In which:

$k_{t_{sn}}$ is the order t cumulants of n^{th} cross.

$k_{t_{ii}}$ is the order t cumulants of return to i^{th} route, which is ended to the cross number n.

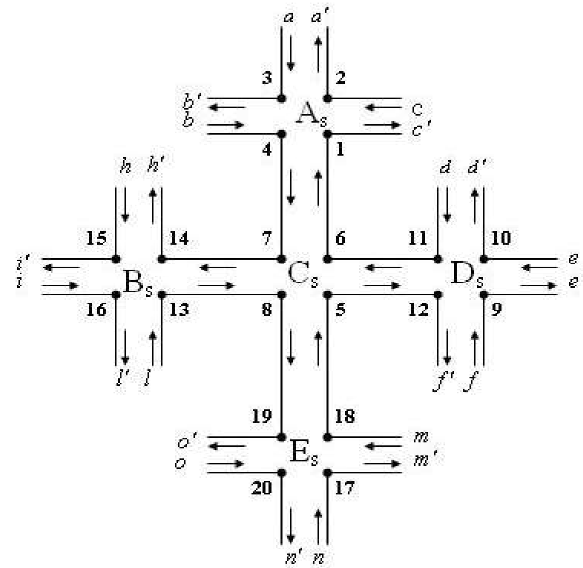

Fig. 1: The simulated route with 5 junctions

$k_{t_{ij}}$ is the order t cumulants of the flow from i^{th} route to j^{th} route by crossing the n^{th} cross.

$k_{t_{start}}$ is the order t cumulants of the flow, which is started from routes ended to n^{th} cross.

$k_{t_{stop}}$ is the order t cumulants of the flow, which is stoped in routes ended to n^{th} cross.

p is the number of cross in each period time of process.

As our goal is to plan controlling many junctions simultaneously, we have to determine the situation of lights in many junctions. In addition each traffic light can affect other junctions the evaluating function is a mixture of traffic flow of all junction. The weight of each junction is adjusted based on importance of the junction.

$$f = w_1 f_{s_1} + \cdots + w_5 f_{s_5} \qquad (4)$$

subject to

$$w_1 + \cdots + w_5 = 100\% \qquad (5)$$

In which w_i is the importance of moving traffic in ith junction per percent. The f_{s_i} is the mean value of pdf if it is normal as assumed in this work.

As we control the traffic lights any decision restrict to a time period. As our decision has two situations allowed or forbidden, the genetic algorithm is used. The result of algorithm is a state that makes the traffic in the route the best with maximum likelihood. Minimizing summation of the weighted variance of the junctions' traffic flow leads to the estimation approach the reality.

$$R = w_1 \delta_1^2 + \cdots + w_5 \delta_5^2 \qquad (6)$$

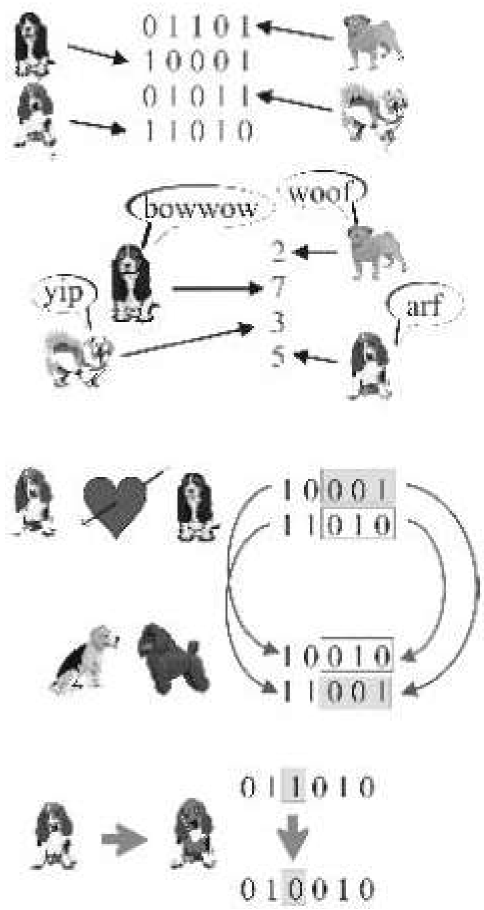

Fig. 2: Translating dog generation based on GA [15]

0	0	1	1	1
A_S	B_S	C_S	D_S	C_S

Fig. 3: A sample resulted chromosome

In which δ_i^2 is the variance of pdf of the moving flow in ith junction. The result of minimizing of the above function is minimizing of flow variance in each junction based on their importance. As we know minimum variance result in putting mean instead of variable with higher precision.

The genetic algorithm is based on generation in nature. Figure 2 illustrates this algorithm for dog generation.

In this work it is assumed that in each junction the streets in a line have the same traffic light situation. Other kinds of traffic control, such as three time traffic lights can be modeled in the same way easily. We assume when a vehicle allowed to cross the junction can choose any street (straight, turning left or right is allowed). This is why the state of each junction is modeled as a gen with two states.

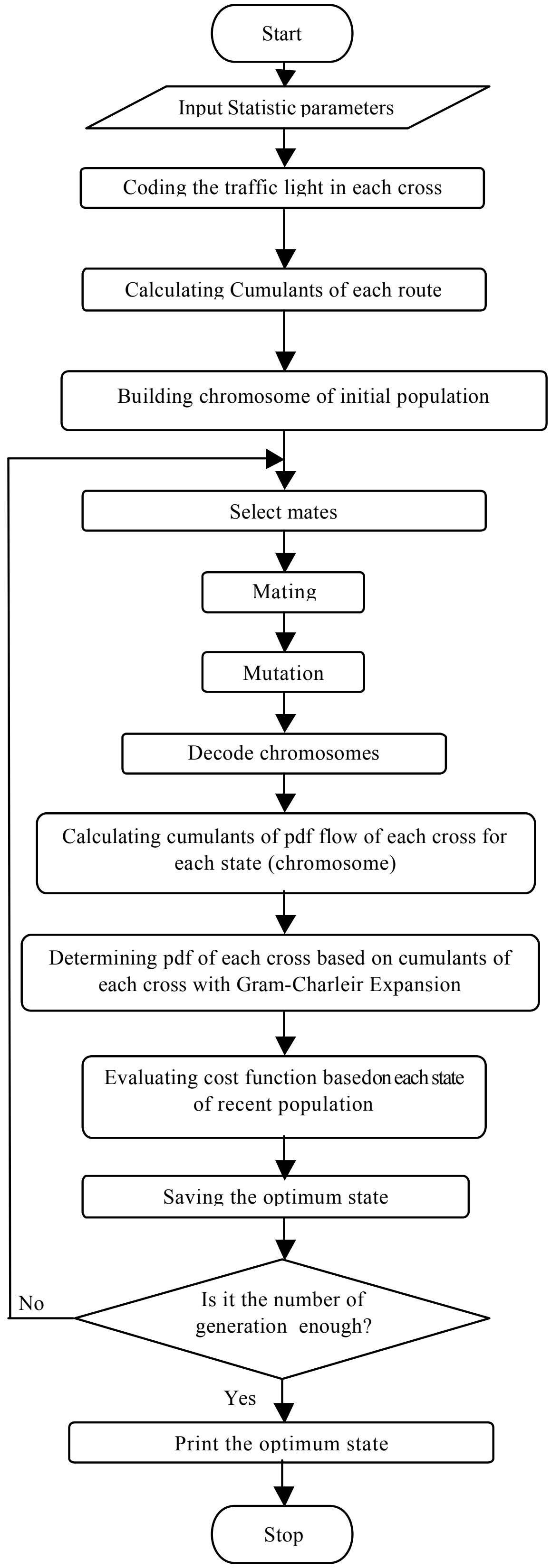

Fig. 4: The flow chart of method

Table 1: Simulation results

Route	Weight A	B	C	D	E	Optimum state	Opt
E C D	0.00	0.00	0.42	0.31	0.27	1 0 0 1 0	293.0840
A C	0.50	0.00	0.50	0.00	0.00	1 0 0 0 1	425.00
B C D	0.00	0.20	0.60	0.20	0.00	1 1 0 1 1	408.07
B C A	0.33	0.33	0.34	0.00	0.00	1 1 0 0 1	334.9420
B C D E	0.00	0.25	0.25	0.25	0.25	1 1 0 1 1	445.087
E C A D	0.23	0.01	0.31	0.20	0.25	1 0 0 1 1	688.49
A C E	0.30	0.00	0.50	0.00	0.20	1 0 0 0 1	93.55
B C E	0.00	0.30	0.45	0.01	0.24	1 0 0 1 0	196.43
B C	0.05	0.45	0.46	0.025	0.025	1 1 0 1 1	536.98
A C D	0.24	0.01	0.50	0.23	0.00	1 0 0 0 1	96.50

In order to investigate all junction simultaneously, all gens are put together and make a chromosome. The result of applying the algorithm is a chromosome which shows a programming for all junctions.

Many possible programming for the junctions are considered as initial population of chromosome. Then parents for matting are chosen based on fitting function which is known as Rollet wheel. The single point crossover method used for offspring results. Mutation is simulated as changing state of gen from 1 to 0 or vice versa. Such gen is chosen randomly.

The result chromosome is decoded to indicate the situation of traffic lights. For example Fig. 3 shows such chromosome. It means the odd traffic lights are green in junction A_S. In other word the vehicles in street *a* and C_SA_S allow crossing the junction. Whereas the even traffic lights are green in junction C_S,D_S and E_S.

The resulted chromosme is maximize the following validation function:

$$F = f + w_R \frac{1}{R} \qquad (7)$$

In which w_R is the weight of reliability.

Such chromosome guarantee the maximum moving traffic in junction based on importance of the junction and rality of estimation.

SIMULATION RESULTS

We assume probability density function (pdf) of traffic flow in each junction is normal. Figure 4 shows the simulation route.

The result of simulation put in Table 1. Ten different path in the route with different weight in each cross is assumed. For example E C D means the flow in three cross named D_S, C_S and E_S are considered. The result of simulation is based on weight and flow of all cross and route. The optimum state in the first row of the Table 1 means in A_S and D_S the lights with even number are green and in other cross the lights with odd number are green. Although the considered route is D_S, C_S and E_S, but the situation in other route can influence the flow in this route. The details of junctions and routes information do not bring here for keeping shortage.

CONCLUSION

There is a period time for simulation. The period time depend on the length of the route and the mean speed of the cars. Based on the Table 1 the new method is work and optimum state reach based on different state in different route and junctions.

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