Analysis on the Application of Control Algorithms in Computer Simulation of Traffic Flow Control of Highway Networks

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***Abstract* — To improve the accuracy and efficiency in simulating the traffic flow control process, a control algorithm is presented in this paper. The application of traditional computer control algorithm in control simulation also faces the problem that the source program must be revised once the monitoring target changes. As a result, development cycle and maintenance cost increase while production efficiency of enterprises and develop efficiency of users decrease, and the control algorithm cannot be fully used in computer. This research proposes the analysis on the application of control algorithm in computer simulation on control algorithm, namely configuration inspection simulation. In the simulation platform and development environment of automatic monitor layer, configuration inspection simulation could provide plenty of flexible ways and better interface for user, and is easy to use. This method can solve the problems in traditional industry control and the control algorithm can be applied in practical production more conveniently and effectively. At the same time, control model can be perfectly combined with computer simulation on control algorithm to improve the production efficiency, reduce production costs and accelerate the development of region traffic.**

Keywords - control algorithm; accuracy and efficiency; traffic flow control; highway network

I. INTRODUCTION

With the rapid development of modernization, computer simulation on control algorithm is more and more used in industry. Higher and higher automation requirements are made by producers and developers. In modern industry field, all kinds of computer control devices and process monitors are broadly used, which results in the problem that the traditional computer industry control simulation failed to satisfy clients. The application of traditional computer control algorithm in control simulation also faces the problem that the source program must be revised once the monitoring target changes. As a result, development cycle and maintenance cost increase while production efficiency of enterprises and develop efficiency of users decrease, and the control algorithm cannot be fully used in computer. This research proposes the analysis on the application of control algorithm in computer simulation on control algorithm, namely configuration inspection simulation. In the simulation platform and development environment of automatic monitor layer, configuration inspection simulation could provide plenty of flexible ways and better interface for user, and is easy to use. This method can solve the problems in traditional industry control and the control algorithm can be applied in practical production more conveniently and effectively. At the same time, control model can be perfectly combined with computer simulation on control algorithm to improve the production efficiency, reduce production costs and accelerate the development of enterprises.

With the speeding-up production rate, expanding scale and rapid development of computer control technology, the application of computer control technology in production field has improved the production efficiency of enterprises and the development efficiency of developers in some degrees. In the development and application of industry control technology, computer (including IPC) has obvious advantages over the previous system [1]. Computer has rich simulation resources and hardware resources, simulation has great interoperability, and computer control system is easy to learn and use. Still there are many inevitable problems, such as revision of source program after monitoring target changed will decrease the efficiency and increase the maintenance costs. This research analyzed the application of control algorithm in configuration inspection simulation (SCADA) for its powerful interface display, friendly user interface and simple operation and other advantages. In addition, this simulation has excellent openness and diverse functional modules, which can tackle the problems in traditional computer control simulation and give full rein to control algorithm and computer in practical production.

With the increasing of the vehicle and traffic pressure, obviously all countries in the world is faced with the problem of traffic congestion. Due to the effects on the economic and environment, traffic jams is beyond question. Therefore, Meramat's study [1] proposes a novel real-time traffic controlling system which takes advantage of Vehicle Ad-hoc Network (VANET) and vehicle platoon system. The proposed system comprises two main phases. The first phase, based on VANET detection of traffic flow and traffic signal control system has put forward. The phase includes estimation of vehicles' density in road segment leading to intersection by utilizing the combination of Vehicle-to-Vehicle (V2V) communication and Vehicle-to-Infrastructure (V2I) communication for transfer-ring the acquired information to the Traffic Controller. Then it contains assessment and analysis of obtained data from the above to

create various adaptive traffic signal cycles to control the traffic congestion. The most distinct capability of this approach which makes it more effective in comparison with fixed timing cycle control, is controlling the traffic flow of vehicles in adjacent intersections by considering the future destination of vehicles and anticipation in traffic signal timing of contiguous intersections.

II. Computer simulation frame for traffic flow control system

As economy and society developed, traffic has become the indispensability part of life; it has more and more effect on guaranteeing the economic system and human life. In recent twenty years, traffic network has been established faultlessly by many countries, but, building new roads and other traffic facilities cannot meet the fast increase of the amount of vehicle, so more traffic problems such as traffic jam, environment pollution, and traffic accident emerge, which cost huge expense. As above, improving traffic by building road and facility or managing traffic in conventional way costs dearly and pollutes environment seriously, it also has little effect on relaxing traffic jam and advancing traffic. More than one hundred years have passed since the problem of traffic control was presented, and the control theory has developed for more than sixty years, but the research on dynamic characteristics of traffic flow using control theory is still a difficult job due to complication and the inherent uncertainty of traffic flow which bring lots of problems on traffic control study.

Traffic problem has become the main problem of society all over the world. How to decrease the influence using modern science and technology is the emphasis of research in the field. At present, with the rapid economic development, accelerating the urbanization process, the number of vehicles maintains rapid growth in traffic. Therefore traffic problems as the important bottleneck seriously constrain urban development and quality of life for residents. The face of rapid increases in vehicle traffic volume and limited resources, how to relieve a wide range of traffic congestion, improve road network capacity, reduce the number of traffic incidents to avoid the waste of valuable resources into Urban Road Network Management urgently needs to be resolved problem. Regional Traffic Control (RTC) as Intelligent Transportation System key technology, as it can significantly alleviate these traffic problems, with the social significance and economic value, will be the next hot field of intelligent transportation and key.

In Qi's [2] paper, in order to achieve effective to ease traffic flow for the purpose of information in a wide range of reading, his paper summarizes the current status of research in the field of traffic control, including the intersection traffic control research and development, Route Traffic Control research and development, regional traffic control research and development. Particularly on Intelligent Computing in research and development of traffic control were introduced, the commonly used methods of computational intelligence: fuzzy control, evolutionary computation, neural networks are described in the application of traffic sector Research. At the same time as the necessary preparations for the follow-up section, an overview is given about traffic control important parameters and concepts in the process of traffic control.

To a typical single-intersection region as the control object, Mu [3] constructs a single intersection discrete traffic model. In this model, the release of vehicle traffic and vehicles enter the constant arrival rate to queue length for the system state variables, through program design and implementation of traffic modeling, using small step test method optimized green time, reduce the queuing length, thereby validate the model simulation of the effectiveness of intersection conditions.

For a fixed phase isolated intersection traffic flow control problem, including phase change proposed fuzzy controller and fuzzy controller for two-stage fuzzy control method, in which the phase transformation of fuzzy controller to judge the phase transition, delay fuzzy controller determine the delay of the green time, Zhang's paper [4] researches on the text on the two fuzzy controller to achieve the given design process, the simulation compared with the sensor control obtained, this method achieved the green light to shorten the delay time, reduce delays, make access more the purpose of smooth, but the adaptation effect of saturation by the traffic situation.

Considering multi-junction area traffic control complex, stochastic, discrete strong interference characteristics of many factors, the multi-agent control structure of the region is proposed in Ruan's [5] based on multi-agent technology built of loosely coupled relationship and their control structure design of Intersection-level multi-agent, control structure design of regional multi-agent, structure design of the center control multi-agent are given a detailed description. In particular the simulation process to a regional multi-agent controller on the intersection traffic unit as the research scope, focus on the two junctions in the traffic jam situation of appears to coordinate the solution process. When the regional level agent faces intersection level agent coordination request, the genetic algorithm is used an important tool to optimize control parameters to achieve the overall regional traffic flow optimization. The results show that under the same conditions, compared with the traditional timing control, the index performance is greatly improved and this method is effective and feasible.

The urban traffic jam problem is one of the important problems facing the world today. There are many measures to solve traffic jam, such as new roads, widening of roads, etc.. These measures eased the traffic jam problem to some extent, but they all don't resolve this problem thoroughly. Traffic control coordinated with traffic guidance is a fundamental means to solve traffic jam problems. Traffic control is to control vehicles which already happened and will pass crossroad, the result is to change the time of the different direction vehicles passing the crossroad, so that in time distribution the network flow will change in order to maximize the current road traffic capacity. Its main role is to control through laws and use of traffic signals so that vehicles in an orderly manner away from conflict zones, it is a compulsory means to solve traffic jam. Urban traffic flow on the road has great randomness and strong uncertainty; it is not very satisfactory to use the traffic control to solve the

traffic jam problem only. Traffic guidance attempt to avoid future traffic jam or ease traffic jam, directly adjusts the traffic flow that to be adopted in the spatial distribution. Traffic control and traffic guidance can learn from each other, give full play to their strengths, also can play its collaboration features. It has great role to solve traffic jam problems. Traffic control coordinated with traffic guidance is the main development direction of ITS. Tang's [6] paper presents a new model of traffic control coordinated with traffic guidance. The model has two sub-models, model One reflects the thought of traffic jam dissipation and balanced road network flow, its goal is to balance network saturation and minimize the variance of saturation. The goal of model Two is system optimization or minimizing total travel time. It uses genetic algorithms and optimization function to solve the model. At last, it uses a simple road network to test the validity of models and algorithms, comparatively analyzed the results of two methods. It provides some theoretical support for the implementation of urban road traffic control coordinated with traffic guidance.

III. INTRODUCTION OF COMPUTER TRAFFIC FLOW CONTROL SYSTEM

In the control of industrial production, many control objects have pure delay property, and the delay time τ will reduce the system stability and dynamic capability and result in overshoot and sustained oscillation. If the ratio of pure delay time τ to time constant T_c is larger than 0.5 that is $\tau / T_c \geq 0.5$, regular PID will have difficulties to adapt, resulting in severe overshoot and less stability [2]. Otherwise, Smith predictive control algorithm can well resolve pure delay problem by certain compensation.

For single loop control system which is shown as Fig. (**1**), parameter D(s) in traditional pure lag control system is the transfer function of regulator and is mainly used to correct $W_p(s)$ part. Parameter $W_p(s)e^{-\tau s}$ is the transfer function of the object, the transfer function of pure delay is not concluded in $W_p(s)$ objects, and parameter $e^{-\tau s}$ is the transfer function of pure delay object.

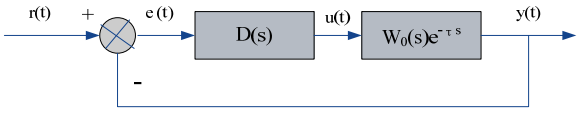

Figure 1. Control system of pure lag component.

Principle of Smith predictive control algorithm is to merge $W_p(s)e^{-\tau s}$ with D(s) as compensation part to compensate for pure lag of control target. This compensation part is usually called predictor, its transfer function is: $W_p(s)(1-e^{-\tau s})$, τ is pure lag time. Compensated system diagram is as shown in Fig. (**2**):

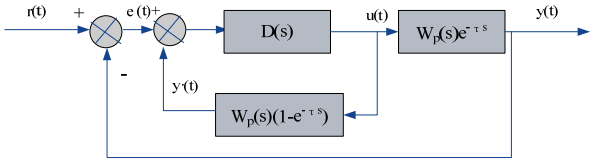

Figure 2. Control system with Smith predictor.

(1) Transfer function of pure lag compensator is $D'(s)$:

$$D'(s) = \frac{D(s)}{1 + D(s)W_p(S)(1-e^{-\tau s})} \quad (1)$$

(2) Closed loop transfer function of compensated system is:

$$\Phi(s) = \frac{D'(s)W_p(s)e^{-\tau s}}{1 + D'(s)W_p(s)e^{-\tau s}} = \frac{D(s)W_p(s)}{1 + D(s)W_p(s)}e^{-\tau s} \quad (2)$$

Compensated close loop system is much more stable because lag parameter is out of the close circuit and its control performance reduces lag performance.

Digital filtering is a processing procedure during which the signals in a certain frequency band are filtered through a series of treatment by some algorithm. As a result, there are less interference signals in the new signal and the truth of the signal is improved. Up to now, some digital filtering methods in common use is: limiting filtering method, median filtering method, mean filtering method and continuity filtering method and so on.

Median filtering method is to take samples on a parameter continuously for N times (N is usually odd numbers), arrange the samples according to size, and take the median as sampling value. Hypothetically, sampling values are y_1, y_2, y_3, and $y_1 \leq y_2 \leq y_3$, then y_2 is the most effective signal [3]. Median filtering can reduce pulse interference and gain great results in slowly varying application. Arithmetic mean filtering method is usually used to filter random interference signals but it also results in low sensitivity. Recursive mean filtering is to regard the sampling statistics as a queue with a fixed length N, add new sample data at the end of this queue and drop the first sample data, then calculate the arithmetic mean of these N data in the queue, its expression is:

$$\bar{y} = \frac{1}{N}\sum_{i=0}^{N-1} y_{n-i} \quad (3)$$

Different digital filters have different advantages in practical production, so it is important to adopt proper digital filter to get best results. Mean filtering method is more suitable for periodic interference, median filtering method and limit filtering method is more suitable for occasional pulse interference, continuity filtering method is more used in high frequency signal or low frequency signal, and weighted mean filtering method is mainly used for large pure time delay control object.

In practical project, the most commonly used control rules of regulator are proportional control, integral control and differential control, which is called PID control or PID

regulation. In modern production field, industrial automatic level is a major factor to compare modernization level of different industries. There are many kinds of PID control, PID controller and intelligent PID controller (instrument) which are widely applied in practical project operations. It has become one of the major technologies for industrial control to obtain various PID controllers with simple structure, reliable stability, easy adjustment and so on.

Supposing that Fig. (**3**) shows the diagram of the PID regulator, with its relationship of input to output is proportional-integral-differential, namely:

$$U_{(s)} = K_p E(s) + K_i \frac{E(s)}{s} + K_d s E(s) \qquad (4)$$

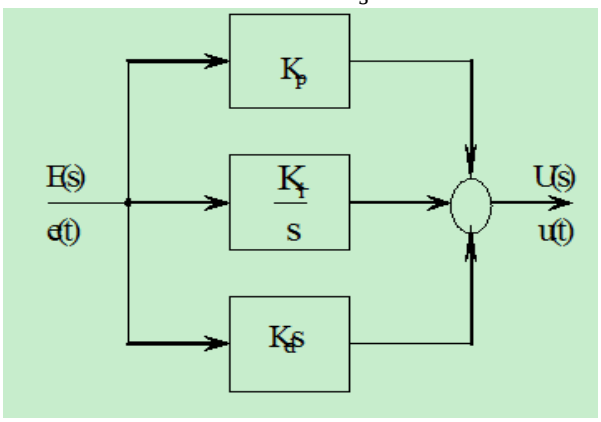

Figure 3. Regulator diagram.

If the transfer function is shown as Formula 2-5:

$$D(s) = \frac{U(s)}{E(s)} = K_p + k_i \frac{1}{s} + k_d s \qquad (5)$$

Among formula 5, T_i is integration time constant, T_d is differentiating time constant, K_p is proportional coefficient, $K_i = \frac{K_p}{T_i}$ is integral coefficient, $K_d = K_p K_d$ is called differentiating coefficient.

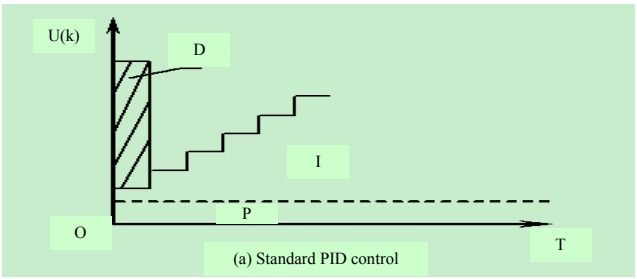

Figure 4. Standard PID control.

Adding integration into integral separate PID control algorithm will generate large overshoot. While connecting a series inertial first-order system to PID control output will play the role of incomplete differentiation PID controller, and many problems will be resolved. Thus, using integral separate algorithm in improved system will reduce overshoot while keeping integral effect. The effect of standard PID control algorithm in unit step input and output is as shown in Fig. (**4**), and the effect of incomplete differentiation PID algorithm in unit step input and output is as shown in Fig. (5).

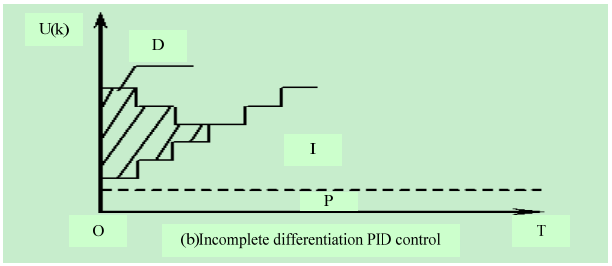

Figure 5. Incomplete differentiation PID control.

Fig. (4) shows that standard PID control algorithm only shows differentiation effect in the first sampling period and the effect is strong. Fig. (**5**) shows that incomplete differentiation PID control algorithm shows differentiation effect in longer time, that is to say incomplete differentiation PID control has better control effects.

IV. Application of Control Algorithm in Configuration Inspection Simulation

Configuration inspection simulation is a kind of simulation usually used in data acquisition and process control; it can provide simple operation methods and developing methods for operation interface to users in various configuration modes (not program modes), tackling generality problem of control system. And all kinds of simulation modules in configuration inspection simulation are set up in advance, which can rapidly realize and complete every function requirement of monitoring layer as well as supporting computers and I/O products from different hardware vendors. Configuration inspection simulation can also be connected to industrial control computer and network system, provide interface of all kinds of simulation and hardware to control layer and management layer, and integrate system [5]. This research briefly introduces the following functions of configuration inspection simulation:

(1) Strong interface display configuration function. Industrial configuration inspection simulation is mainly used in Windows operating system in order to get beautiful interface by Windows graphical function and make it convenient and time-saving for operators to develop directly through various toolbars. In addition, there are many drawing tools for users to draw their own industrial interface and edit or modify it, which makes the design free and easy and the interface vivid and concise.

(2) Good openness. Openness is an important indicator to judge configuration inspection simulation. Parts of the entire system may not come from the same developer or manufacturer because of rapid social development and different functions division, “heterogeneity” is a feature of

control system. Configuration inspection simulation can be connected with many communication protocols and support all kinds of hardware devices [6].

(3) Various functional modules. Various control functions can meet the users' field requirement and measurement and control needs. Various functional modules can realize real-time monitoring and warning function make functional statement, display history curve and real time curve. Well-designed user operational interface is easy to operate.

(4) Powerful database. Real-time database can store a lot of data materials such as analog data, discrete data, character data, and exchange data with external equipment.

(5) Reliable security system. Different users have different access authority, and operation system can be modified, which ensures the system secure.

(6) Powerful emulation function. It enables the system to run several functions at the same time and shorts the developing period.

Configuration inspection simulation usually consists of increasing and increasingly strong components such as graphical interface system, real time database system and third-party data interface, it generally adopts the object-oriented programs and designing ideas.

When making the figure, the main pictures of on-sited process can be simplified into three relatively simple objects, including line, shape needs to be filled, and text. There are various functions on the graphical interface, such as warning notice, confirming notice and copy notice, whose data can be decided according to configuration [7]. This enables engineers to set every picture freely with no limit on the number of the objects in each picture.

The part of communication and third-party program interface is a main symbol of an open system and an important means to realize interaction and long-distance data visit between configuration inspection simulation and third-party program. It has the following effects [8]:

Connect host computer and slave computer in dual-computer redundant system;

Connect computers in building distributed HMI/SCADA application;

Realize communication function in application based on Internet or Browser/Server.

The phase contains assessment and analysis of obtained data from the above to create various adaptive traffic signal cycles to control the traffic congestion. The most distinct capability of this approach which makes it more effective in comparison with fixed timing cycle control, is controlling the traffic flow of vehicles in adjacent intersections by considering the future destination of vehicles and anticipation in traffic signal timing of contiguous intersections.

Some functions in communication component are relatively independent programs; they can be operated and used alone. And some functions are locked in other programs; they cannot be obviously operated and used.

At present, with the rapid economic development, accelerating the urbanization process, the number of vehicles maintains rapid growth in traffic. Therefore traffic problems as the important bottleneck seriously constrain urban development and quality of life for residents. The face of rapid increases in vehicle traffic volume and limited resources, how to relieve a wide range of traffic congestion, improve road network capacity, reduce the number of traffic incidents to avoid the waste of valuable resources into Urban Road Network Management urgently needs to be resolved problem. When the regional level agent faces intersection level agent coordination request, the genetic algorithm is used an important tool to optimize control parameters to achieve the overall regional traffic flow optimization. The results show that under the same conditions, compared with the traditional timing control, the index performance is greatly improved and this method is effective and feasible.

V. CONCLUSION

This research comprehensively elaborated the reason, basic characteristic and function of configuration inspection simulation, and briefly introduced the principle and application of computer control algorithm. As configuration inspection simulation becoming the main system applied in modern traffic flow control, both of the users and hardware producers can use the configuration inspection simulation as a main tool to collect information and integrate. This requires configuration inspection simulation having many functions to meet region traffic needs and ensure special traffic request for redevelopment. Using configuration inspection simulation can solve technical problems and merge the technical design with control in optimizing process. Taking the final plan and its effect as well as technical design into consideration can resolve problems which may make control difficult, and this method attracts more and more attention.

In the background of rapid development of industrial control, configuration inspection simulation is more and more applied in project for its great inspection function and relatively simple operation. However, there are still some problems in configuration inspection simulation to be improved and resolved. At present, the functions of configuration inspection simulation are still limited on inspection layer and lack of control ability. And new control algorithms are created continuously owing to the rapid development of computer technology. But it still requires further research to merge these algorithm technologies with computer algorithm on control simulation technology in the practical production, and figure out a simple way to optimal operate.

REFERENCES

[1] A. Meramat, N. F. Rajab, S. Shahar,Razinah Sharif, "Cognitive impairment, genomic instability and trace elements". The journal of nutrition, health & aging, vol. 1, No.19, pp. 54-65, 2015.

[2] Qi Wenxin, Zhou Xuewen. "Design and application of distributed intelligent greenhouse computerized control system". Transactions Of The Chinese Society Of Agricultural Engineering, vol. 20, pp. 246-249, 2004.

[3] Mu Shanxiang, Zhang Qijun. "Development and Application of Gas Engine Computer Control System". Small Internal Combustion Engine and Motorcycle, vol. 42, pp. 59-62, 2013.

[4] Zhang Yuhua. “Research Application of Control Algorithm for Configuration Simulation”. HoHai University, 2008.

[5] Ruan Xuebin. “Application of Generalized Predictive Control to Air-condition Monitor and Control System”. Control Engineering Of China, vol. 14, pp. 18-20, 2007.

[6] Tang Yongjian, Cheng Liming. “Research Application of Control Algorithm for Configuration Simulation”. Computer Cd Simulation And Applications vol. 16, pp. 92-93,2010.

[7] Shao Lianhe; “The Simulation and Study of Arithmetic of the PID Control”; Chengde Petroleum College; 2009.

[8] Doan, K.H.; Busath, J.L.; Kellman, D.H., "The DIII-D Neutral Beam Supervisory Control and Data Acquisition workstation upgrade,"Fusion Engineering, 2002.