Advances in Science, Technology and Engineering Systems Journal Vol. 7, No. 4, 24-27 (2022)
www.astesj.com
ASTESJ
ISSN: 2415-6698

Using Dynamic Market-Based Control for Real-Time Intelligent Speed Adaptation Road Networks

Jamal Raiyn*

Al Qasemi Academic College, Computer Science, Baqa Al Gharbiya, 30100, Israel

ARTICLE INFO

Article history:
Received: 08 February, 2022
Accepted: 16 April, 2022
Online: 18 July, 2022

Keywords:
Data science
Speed adaptation
Market-Based Control
Computational intelligence

ABSTRACT

Traffic road management is becoming more complex due to limited resources and an increasing number of hybrid vehicles. Currently, a number of global classical computing tools are used to manage the traffic road network. This kind of classical computing is resource intensive and expensive, and in the best case, optimizing a traffic network takes a few hours. In traffic road networks, some classes of traffic are much more sensitive to communication delays than other classes. Delays in vehicle- to- vehicle communication cause traffic congestion and sometimes accidents. To honor users' preferences and to improve the road network performance, a market –based control approach is proposed that returns results in quantum space. This paper introduces a market-based control scheme with the goal to manage the traffic flow. Market-Based Control (MBC) is an economic model, which provides new solution to improve the travel data management and to reduce the probability blocking rate in connected autonomous vehicle. The Market- Based Model divided into fixed MBC and dynamic MBC.

1. Introduction

Road accidents have received the most attention from researchers due to its impacts economically [1]-[3]. It is proposed various conventional methods to reduce the number of traffic congestion states in road networks, and reduction of their negative effects and improvement of traffic safety [4], [5].

The route traffic management becomes more complex [6], when the number of vehicles increases in the road networks. The market- based control approach is proposed to describe the traffic flow and to handle traffic congestion road networks by considering the real-time traffic flow. In this case, computational intelligent methods are used, as market-based control model. The Market –based control provided different intelligence features, such autonomy, negotiation learn ability and reasoning. The novelty of market-based control is the dynamic management of traffic flow based on provider and supplier strategy.

The paper is organized as follows: Section 2 presents the traffic control problem. Section 3 describes the proposed concept based on market-based control. Section 4 presents the simulation and results' discussion. Finally, the conclusion summarizes the presented work and points to some future research directions.

*Corresponding Author: Jamal Raiyn, Email: jamal.raiyn@gmail.com

2. The Traffic Control Problem

The traffic and road network management problem can be framed in terms of a market-based control model, in which a road network is divided in *m* road sections and allocated *n* activities. The AVs are considered to be consumers and the road sections to be the producers.

The supply of the producer *l* is expressed by r_{lS}.
The demand of the consumer *i* is expressed by r_{iD}.
consumer: $J_i(r_{iD}) \quad \rightarrow max$
producer: $J_l(r_{lS}) \quad \rightarrow max$
s.t. $\quad \sum_{i=1}^{n} r_{iD} = \sum_{l=1}^{m} r_{lD} \geq 0. \qquad (*)$
$r_{iD} \geq 0 \quad f.a.i$
$r_{lS} \geq 0 \quad f.a.l$

The optimization problem (*) is a road network management problem. The objective functions should be maximized at the same time. $R_{j(t,k)}$ is considered the total resources, and j is the activity that changes within road sections and within a designated time period. The activity of each road section j is presented as $x_{j(t,k)}$.

$$\sum_{i=1}^{m} x_{i,j}(t,k) = R_j(t,k), \ 1 \leq i \leq n$$

https://dx.doi.org/10.25046/aj070404

Market- based control is employed to manage the traffic and the road network. To maximize utility, a given AV demands road sections with a minimal cost. The operator supplies road sections (resources) at a minimal cost to maximize its profits by offering available, road sections affording zero delay. The factors that influence the road traffic are expressed as cost functions that should be detected and reduced to zero. The cost functions consist of noise, delay and other factors that have a negative effect on road traffic. The cost functions can be collectively expressed as a general formulation:

$$J_k = \sum_{i \in I_C} (C_{ki} q_{ki}) + q_c C_k$$

for $\forall c, \forall k$, *where,* J_k presents the cost units for is the data anomalies in *k*th road sections, I_c denotes the sets of anomalies related to a cluster of road sections, and *C*. C_{ki} denotes the binary status of I_c which breaks down as

$$C_{ki} \begin{Bmatrix} 0, if\ there\ are\ no\ anomalies \\ 1, if\ there\ are\ anomalies \end{Bmatrix}$$

and q_{ki} is used to reflect anomalies between the two neighboring road sections and is taken from the anomalies matrix (i.e., $q_{ki} = m_{ij}(t)$). The road section strategy is to keep the supply higher than the minimum supply.

Road section / Anomalies	section 1	section 2	section 3	section5
Delays	V	X	X	V
Noise	V	V	X	X
Accidents	V	X	X	X
Road work	X	X	X	X
Interference	X	X	X	X
Environmental factors	V	X	X	X
Human behavior	X	V	X	X

3. Market- Based Control Model

3.1. Classical Market-Based Control

In classical market-based control, there are three main components: Road section, autonomous vehicle, and a cognitive agent. The cognitive agent manages the negotiation between road section and autonomous vehicle. The road bids a resource in position *k* at time *t* with the price $P_k(t)$. The price of the resource $x_k(t)$ is affected by cost function. The cost function is affected by noise and delay. The autonomous vehicle searched resources with minimal cost function.

- Road traffic utility

The goal of road traffic is reducing the traffic congestion in road section *i* at time *t* and detecting the factors that caused congestions.

$$U_i^s(t) = P_i(t) \sum_{j=1}^{n} x_{ij}(t)$$

- AV utility

The goal of the AV is saving time, avoiding congestion, reducing CO_2.

$$U_i^b(t) = -\sum_{j=1}^{n} P_i(t) x_{ij}(t)$$

- Cognitive agent utility

The goal of cognitive agent is to manage a negotiation between AV and road section to assign road section (resources) with minimal cost.

$$U_i(t) = \sum_{j=1}^{n} x_{ij}(t)/N_i$$

Today, the digital devices, algorithm and data presentation are used classical computing. The road sections state is described in binary format, i.e. 0,1.

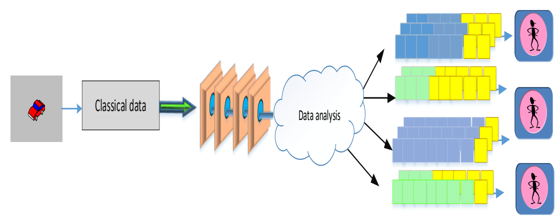

Figure 1: Fixed market-based control

3.2. Dynamic Market-Based Control

By using fixed market based control, all autonomous vehicles received update about the traffic sates at the same time, that performed in t_0. For that, when using normal car navigation systems, with the aim to avoid traffic jams are presented for each individual vehicle; however, because all vehicles are received nearly identical routes, the vehicles concentrate along the same route, causing traffic congestion. In dynamic market-based control, the road traffic is calculated in distributed mode, in different time slots, and according to AV demands. In distributed mode, the system estimates the traffic based on individual AV demands. Dynamic market based control model can present differing best routes for each of many vehicles that have the same starting points and destinations by distributing their routes as much as possible. Dynamic market-based control can prevent traffic congestion before it occurs instead of merely mitigating it.

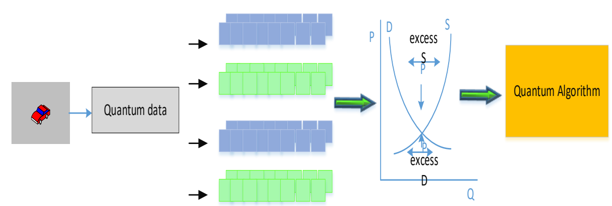

Figure 2: Dynamic market based control

4. MBC oriented computational Intelligence

The operations of the system model consist of four main phases: traffic road sensing; creating neural networks based on multi- layered deep learning technology, detecting anomalies and allocating resources as illustrated in Figure 3. The cognitive GOA obtains the road network, divides the roads into sections, and assigns a neuron to each road section to manage the traffic. The neuron aims to detect data anomalies and the factors that cause them. Then the road sections are classified by the effects of the anomalies, and on each road section is assigned a score that indicates its quality. The highest-scoring road sections offer balanced service, where the demand (for available road) is equal to the supply. If the demand is greater than the supply, it means, there is traffic congestion in road section. The traffic flow in the road section is dynamic which is described by using binary bits (0 and 1) along with the option of the bit being both 0 and 1 at the same time (superposition), this creates the third state. Eventually 3 states are 0,1 and 0–1. Quantum bit or Qubit is the basic unit of quantum information, that can be in a state of both 0 and 1 at the same time. The 3rd state creates more processing power. How states are processing in 3-bit systems described below.

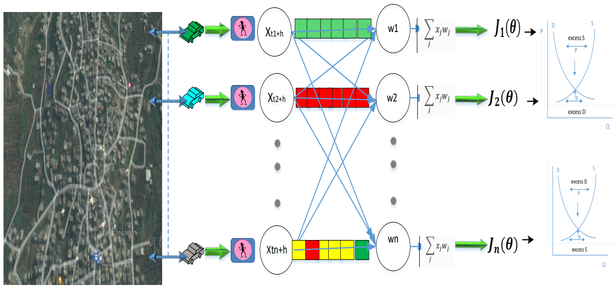

Figure 3: System model

5. Discussion and Evaluation

Travel data is collected by several tools, such as the magnetic loop detectors [7] and mobile services [8]-[14]. Traffic congestion appears when too many vehicles attempt to use a common transportation infrastructure with limited capacity [15, 16]. For a successful forecast of traffic flow, it ought to update the local travel data. Furthermore, it is important that the forecast model takes into consideration the anomalies data that caused in real-time [17]-[20]. Today, the digital devices, algorithm and data presentation are used classical computing which are described in binary format. As result, the road section state is described in binary format also as illustrates Figure 4. A fixed market-based control model is used in road traffic management, which evaluates a road network at time $t=0$ for all road sections, despite the fact that traffic varies from section to section and changes from moment to moment. To overcome this disadvantage, a dynamic market- based control model is introduced, which assesses road sections at differing intervals of time, based on the condition of the traffic in each section as illustrates figure 5. The road section is described on quantum computing. Quantum computing uses binary bits (0 and 1) along with the option of the bit being both 0 and 1 at the same time (superposition), this creates the third state. Eventually 3 states are 0,1 and 0–1. Quantum bit or Qubit is the basic unit of quantum information, that can be in a state of both 0 and 1 at the same time. The 3rd state creates more processing power. How states are processing in 3-bit systems described below. Fixed market-based control can be implemented in Matlab for evaluation and simulation results. However, for implementing an agent goal oriented is needed dynamic environment. The challenge is creating virtual environment that support parallel processing of data in qubit form. The simulation platform will be described in Python to implement input data that is represented in qubit form.

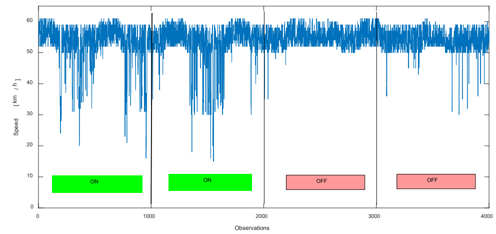

Figure 4: Speed calculation in binary format

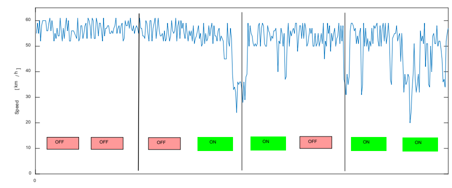

Figure 5: Speed calculation in qubit format

- Data collection

In classic computing, the data is presented in 0,1 which is based on a given threshold. However, in dynamic market based control, the data changes continuous depended on strategy of supplier and demander. In this case, the data is presented in two digits of binary form. One digit for the current state of the road section at time t_0 and one digit for the state of road section after t_0. In fact, the data presentation of dynamic market-based control is the form of quantum data. e.g. it needed qubit form to deal with those data.

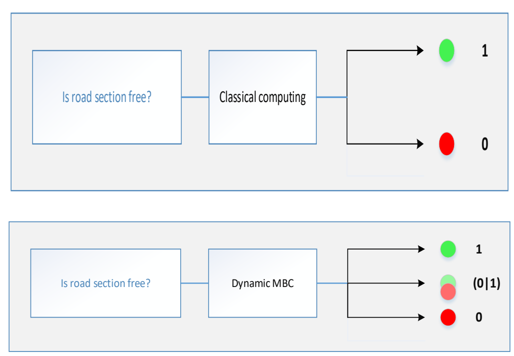

Figure 6: Binary vs. qubite form

- Algorithm based quantum computing

The dynamic market-based control which is proposed to process quantum data is based on advanced deep learning approach. Each road section is assigned a neuron. The task of the neuron is to manage the data in road section. The road section is divided in two parts. The first part is assigned 1 or 0 e.g. free or busy. The second part is described by (0|1) or (1|0) e.g. the traffic flow is in transition from 0 to 1 or 1 to 0 as illustrated in next figure. The road section is assigned a score for current state at t_0 and for transition at t_1.

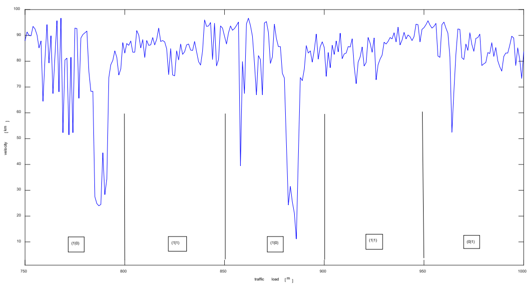

Figure 7: Speed description in qubit

6. Conclusion

Market- Based Model approach provided high reliability and the ability of a very efficient resource allocation even in very complex environments. In this paper, the travel data management is discussed. The travel data has been collected by mobile services. Due to urban coverage lack in cellular system are anomalies data and incomplete data caused congestions and accidents. Thus, the proposed system may play significant role on people life that had direct and positive impact at their life. The evaluation results of the proposed system show that dynamic market based control scheme can detect the any anomaly case early. Furthermore, the forecast results are too closest to the real traffic flow. Future work will consider anomalies data management caused in heterogeneous road networks.

References

[1] R. Elvik. "How much do road accidents cost the national economy?," Accident Analysis and Prevention 32,849-851,2000. http://dx.doi.org/10.1016/S0001-4575(00)00015-4.

[2] A. Alkhatib, T. Sawalha. "Techniques for Road Traffic Optimization: An Overview", Journal of Computer Science and Engineering, v. 11(4). 311-320, 2020. DOI: 10.21817/indjcse/2020/v11i4/201104063

[3] X. Zheng, M. Liu. "An overview of accident forecasting methodologies," Journal of Loss Prevention in the Process Industries 22 (4). 484-491, 2009. http://dx.doi.org/10.1016/j.jlp.2009.03.005

[4] W. Hong, K. Choi, E. Lee, S. Im, M., Heo. "Analysis of GNSS Performance Index Using Feature Points of Sky-View Image," IEEE Transactions on Intelligent Transport Systems, 15(2), 889-895, 2014. **DOI:** 10.1109/TITS.2013.2282631.

[5] J. Gong, Z. Yu, N. Chen. "An analysis of drivers' route choice behavior in urban road networks based on GPS data". In: Proc. of the Int. Conf. on Transportation Engineering ICTE, American Society of Civil Engineers, 515–520, 2007.

[6] L. Berzina, A. Faghri, M.T. Shourijeh, M Li. "Developing of a Post-Processing Automation Procedure for the GPS-Based Travel Time Data Collection Technique," Journal of Transportation Technologies, 4(1), 63-71, 2014. **DOI:** 10.4236/jtts.2014.41006

[7] T.M. Borzacchielo, "The use of data from mobile phone networks for transportation applications," TRB 2010 Annual Meeting, 2010.

[8] M. K. Habib, K. Ilhem, J. Casillas, A. Abraham, M. Alimi,"Adapt-Traf: An adaptive multiagent road traffic management system based on hybrid ant-hierarchical fuzzy model", Transportation Research Part C 42 ,147–167, 2014. DOI: 10.1016/j.trc.2014.03.003

[9] K.K. Santhosh, D.P. Dogra, P.P. Roy. "Anomaly Detection in Road Traffic Using Visual Surveillance: A Survey," ACM Computing Surveys, 53(6). 1-26, 2020. https://doi.org/10.1145/3417989.

[10] Y. Lv, S. Tang. "Real-time Highway Traffic Accident Prediction Based on the K-Nearest Neighbor Method." International Conference on Measuring Technology and Mechatronics Automation, Volume 3, 547-550, 2010.

[11] Z. Xiaoqiang, L. Ruimin, Y. Xinxin. "Incident Duration Model on Urban Freeways Based on Classification and Regression Tree." 2nd International Conference on Intelligent Computation Technology and Automation, TRB 2010 Annual Meeting, 2, 526-528, 2010. DOI:10.1109/ICECE.2010.934

[12] J. Raiyn. "Using Cognitive Radio Scheme for Big Data Traffic Management in Cellular Systems," International Journal of Information Technology and Management, 16 (3). 301-313, 2017. https://doi.org/10.1504/IJITM.2017.084985.

[13] T. Yucek, H. Arslan. "A Survey of Spectrum Sensing Algorithms for Cognitive Radio Applications," IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 11, NO. 1, FIRST QUARTER 2009.pp. 116-129, 2009. http://dx.doi.org/10.1109/SURV.2009.090109.

[14] X. Zheng, M. Liu. "An Overview of Accident Forecasting Methodologies". Journal of Loss Prevention in the Process Industries, 22, 484-491, 2009. http://dx.doi.org/10.1016/j.jlp.2009.03.005.

[15] J. Andrada-Felix, F. Fernandez-Rodriguez. "Improving Moving Average Trading Rules with Boosting and Statistical Learning Methods." Journal of Forecasting, 27(5), 433-449, 2008. DOI: 10.1002/for.1068

[16] X. Zhang, J.A. Rice. "Short-term travel time prediction". Transport. Res. Part C: Emer. Technol. 11 (3–4),187–210, 2003. doi:10.1016/S0968-090X(03)00026-3.

[17] J. Raiyn. "Speed Adaptation in Urban Road Network Management", 17(2). 111-121. 2016. DOI 10.1515/ttj-2016-0010.

[18] R. R. Andrawis, F.A Atiya. "A New Bayesian Formulation for Holt's Exponential Smoothing", Journal of Forecasting, 28(3), .218-234, 2009. https://doi.org/10.1002/for.1094.

[19] X. Ma, Z. Dai, Z. He, J. Ma, Y. Wang, Y. Wang. "Learning Traffic as Images: A Deep Convolutional Neural Network for Large-Scale Transportation Network Speed Prediction, Sensors, 17(v1), 1-16, 2017. https://doi.org/10.48550/arXiv.1701.04245

[20] B. Chen, H.H. Cheng. "A Review of the applications of agent technology in traffic and transportation systems." IEEE Trans. Intell. Transport. Syst. 11 (2), 485–497, 2010. DOI. 10.1109/TITS.2010.2048313.