Design Traffic Signal Node Based on Edge Computing

Jinyan Yang
Guangdong Institute of mechanical and electrical technology, No.2, toad stone East
Road, Tonghe, Baiyun District, Guangzhou, Guangdong, China.
Email: 674935014@qq.com

Abstract. With the development of economy, the traffic jams are more and more serious. The
traditional timing traffic signal can't make full use of the road traffic resources. In order
to solve this problem, an edge computing intelligent traffic light node is proposed, video target
detection, artificial intelligence and other new technologies are used to realize the effective
control of intersection signals, so as to optimize pedestrian traffic, vehicle delay, traffic
capacity and parking times. The simulation results show that this method can greatly improve
the traffic efficiency and reduce the waiting time of the intersection during normal times. It can
effectively delay the peak period and shorten the peak period.

1. Introduction
With the development of economy, there are more and more cars in domestic cities, and the traffic
jams on urban main roads are more and more serious. The traditional timing traffic signal can't make
full use of the road traffic resources. In special circumstances, the traffic police need to conduct on-site
traffic command and guidance. How to effectively control the intersection signal is the most direct
way to improve the traffic efficiency to alleviate the increasingly tense traffic congestion. Practice
shows that the reasonable signal setting will affect the traffic efficiency of the intersection, and even
maximize the function of the road network. Fu Kaiyan and other scholars proposed to add the KNN
algorithm of difference sequence to predict the non-linear traffic flow, so as to achieve more accurate
short-term traffic state prediction [1]. Chen Cuijiao and other scholars have given the algorithm of
traffic control sub region division based on node state, using this algorithm to achieve effective traffic
guidance and control, and alleviate traffic congestion [2]. Tong Xiaomin and other scholars combine
GMM modeling method with depth neural network to achieve the goal detection of video pedestrian
[3]. Song Tao and other scholars proposed moving object detection based on scene perception [4].
Zhang Yinghui and other scholars proposed moving object detection based on frame difference
method [5].

In this paper, an edge computing intelligent traffic light node is proposed. Based on video target
detection, artificial intelligence and other new technologies are used to realize the effective control of
intersection signals, so as to optimize pedestrian traffic, vehicle delay, traffic capacity and parking
times.

2. Design of Intelligent traffic lights node
The principle of edge computing traffic signal system is shown in Figure 1. It is mainly composed of
device computing traffic indicator lights set at intersections, background cloud computing services and
other functional auxiliary subsystems. The traffic indicator set at the edge of the intersection can guide
and command the traffic of the intersection independently, and can form a complex traffic network
through the Internet to work together.
Edge computing traffic lights node is shown in Figure 2, which have strong computing and analysis ability, the core of which is that high-performance SOC can analyze and process the collected video signals independently. It uses two cameras to collect the video of vehicles in the forward direction and the waiting direction respectively. In addition to working independently, it can also connect to the Internet through wired or wireless networks. Upload the data to the background cloud server through the Internet.

![Figure 1. The Design of Traffic Signal System Based on Edge Computing Intelligent](image1)

![Figure 2. The Structure of Traffic Light Node for Edge Computing](image2)

3. Algorithm Analysis
A typical intersection traffic signal control is shown in Figure 3. Where A, B, C and D are entrances in four directions, and A’, B’, C’ and D’ are exits in four directions.

When the vehicle enters from direction A, it can drive to direction A’, B’, C’ and D’, which cans be described as AA’, AB’, AC’, AD’.

Similarly, when vehicles enters from direction B, it can drive to direction A’, B’, C’ and D’, which cans be described as BA’, BB’, BC’, BD’.

When the vehicle enters from direction C, it can drive to direction A’, B’, C’ and D’, which cans be described as CA’, CB’, CC’, CD’.
When the vehicle enters from direction D, it can drive to direction A', B', C' and D', which are can be described as DA', DB', DC', DD'.

All possible traffic signal control sets are { AA', AB', AC', AD', BA', BB', BC', BD', CA', CB', CC', CD', DA', DB', DC', DD' }, which can be marked with symbols S.

Initially, the control signals set S can be divided into subsets Set partition {S_1, S_2, S_3, ..., S_n }, S_i ∈ S, i ∈ (1,2,... n). Traffic signal compatibility within the set S_i is required.

The period of signal control cycle T can be calculated as T= T_1 + T_2 + T_3 + ... + T_n, Ti is the travel time of traffic signal set S_i.

The calculation formula of vehicle CT passing through the primary signal period T is: CT = CT_1 + CT_2 + CT_3 + ... + CT_n, CTi is the number of vehicles passing the Ti cycle.

The formula of traffic efficiency E is as follows:

\[ E = \sum_{i=1}^{n} \frac{CT_i}{T_i} \]  \hspace{1cm} (1)

WT is the sum of waiting time of vehicles in each passing direction in the primary signal period T, and its calculation formula is WT= WT_AA' + WT_AB' + WT_AC' + WT_AD' + WT_BA' + WT_BB' + WT_BC' + WT_BD' + ... + WT_DD'.

**Figure 3.** Typical intersection traffic signal control

The multi-layer deep learning neural network is used to learn the training control model iteratively. According to the real-time perception and historical state, the optimal traffic signal control set S and signal subset S_i traffic time T_i are given by using the trained model, so as to achieve the goal of maximum traffic efficiency E and minimum waiting delay WT. Figure 4 is the calculation diagram of traffic light node. The vehicle information in the waiting direction of lane and the vehicle information in the forward direction of intersection and sidewalk traffic are sensed by image recognition technology. The historical big data is used to generate historical forecast according to the themes of week, time, holiday, traffic accident, etc., and real-time entry forecast, real-time exit forecast, control signal cycle and second reading.

4. Experiment

Edge computing traffic lights have strong computing and analysis ability. A Raspberry Pi 3B + and two USB camera were used as the development of prototype hardware (Figure 5 show the core prototype hardware). A high-performance SOC Which can analyze and process the collected video signals independently. It uses two cameras to collect the video of vehicles in the forward direction and the waiting direction respectively. In addition to working independently, it can also connect to the Internet through wired or wireless networks. Transfer data to the background cloud server through the Internet. The main function software is developed by python, numpy and tensorflow. Figure 6 shows the processing flow of edge computing node.

The simulation results show that this method can greatly improve the traffic efficiency and reduce the waiting time of the intersection during normal times. It can effectively delay the peak period and shorten the peak period.
**Figure 4.** The Edge Control Algorithm

**Figure 5.** The core prototype hardware
Figure 6. Processing flow of edge computing node

5. Conclusion
Edge computing has the advantages of convenience, flexibility, reliability and adaptability. In this paper, a design scheme of traffic light signal node based on edge calculation is presented, it can also work off-line. Higher reliability. Which uses two cameras to obtain the information of road vehicles and the traffic status of crosswalk; the signal cycle and state can be adjusted automatically according to the unblocked state, vehicle and pedestrian traffic state to improve the road traffic efficiency. The next step is to study how to realize the collaborative work of edge computing traffic light ad hoc network to further improve the traffic efficiency.

6. References
[1] Kaiyan Fu. Short term traffic prediction based on K-Nearest method[C]. Proceedings of 2018 World Transportation Conference of China Association of science and technology, 2018: 887-898
[2] Chen Cuijiao, Zhang Liangzhi. Study on sub-area division strategy of urban road traffic control[J]. Traffic technology, 2018, 7 (5): 351-358. Https://doi.org/10.12677/ojtt.2018.75043
[3] Tong Xiaomin, Ji Xiang, Tong Yin. Video pedestrian detection based on deep learning[J]. Computer science and application, 2018, 8 (10): 1558-1564. Https://doi.org/10.12677/csa.2018.810170
[4] Song Tao, Li ou, Cui Hongliang. Moving object detection method based on scene perception [J]. Journal of electronics, 2016,44 (11): 2625-2632
[5] Zhang Yinghui, Liu Yangshuo. Moving object detection based on frame difference method and background difference method [J]. Computer technology and development, 2017,27 (02): 25-28