30th ITS World Congress, Dubai, UAE, 16-20 September 2024

Paper ID 112

Title of paper
Advanced Traffic Signal Control methods by using network camera

Yuichi Takayanagi [1* 2*], Shunichi Kawabe [2*]

1 Panasonic Connect Co., Ltd.
Saedo-cho 600, Tuzuki-ku, Yokohama 224-8539, Japan
+81-45-938-1551, +81-45-938-1681,
takayanagi.yuichi@jp.panasonic.com

2 UTMS Society of Japan
Airman's Building 7th Floor, 2-6 Ichigaya-Tamachi, Shinjuku-ku, Tokyo 162-0843, Japan
+81-3-3235-6520, +81 3-3235-6522,
kawabe@utms.or.jp

Abstract

We have been considering traffic signal control using network cameras as an alternative to vehicle detectors for past two years, obtained the number of vehicles, occupancy, and right turn congestion length by using AI based on network camera images, and have achieved a certain improvement controlling traffic signals.

This initiative focused on the following three points, and the intersections to be implemented were selected after a field survey of intersections in one district at Y2022 and FY2023.

After approaches, we executed developing and operating traffic demand measurement system including pedestrians and vehicles using single omnidirectional camera and providing low-cost, safe and secure traffic signal control system considering pedestrians.

We will examine the applicability of future left turn control based on this.

In the future FY2024, we will verify capability of the ITV(intelligent television system) almost all prefectures have deployment and apply system in activities of UTMS society of Japan.

Keywords:

AI of network camera,Traffic signal control, Object Detection

Background

The signal control system is required to respond promptly to changes in traffic demand and appropriately update the signal control parameters. Therefore, it is indispensable to grasp the traffic demand accurately and promptly. In Japan, MODERATO control, which determines signal control parameters based on the latest traffic demand calculated from the sum of inflow traffic volume and congestion length, is widely

used, and vehicle detectors for detecting congestion extension are installed on the intersection inflow road. Vehicle detectors are installed in every lanes at multiple loactions.
However, the cost burden for the maintenance, operation, and maintenance of these many vehicle detectors is large, and it is necessary to replace to a low-cost and an efficient traffic control system.The number of vehicle detectors in operation at the end of 2020year in one district was 14,055, and many of them were aging vehicle detectors. Therefore, we utilized the Ministry of Internal Affairs and Communications 5th generation mobile communication system(5G) public-private R & D investment expansion program (hereinafter referred to as PRISM demonstration experiment)implemented in the 2020year, and traffic signal control using a network camera instead of a vehicle detector was verified. In the PRISM demonstration experiment, it was confirmed that the traffic volume, speed, and occupancy rate of the four roads in the intersection can be obtained by utilizing the real-time video stream data of one network camera (Figure.1), and the vehicle detector can be converted to a network camera. Furthermore, this year, we will develop methods by using know-how of PRISM and incorporate the information acquired from the network camera as an input parameter of the traffic control system,and utilize the new acquired information (traffic volume by direction, right turn jam length and information, etc.) for advanced signal control. we had an experiment the possiblity of system.

Approach 1

Network camera images of intersections are distributed to an image estimation device installed at the headquarters (sharing the signal control line), and this device performs AI image analysis processing to estimate traffic volume.
The traffic control system takes in this image estimated traffic volume, generates signal control parameters using the estimation results as input, and performs control by feeding back to the signal controller at the intersection. We shows system structure at Fig.1.

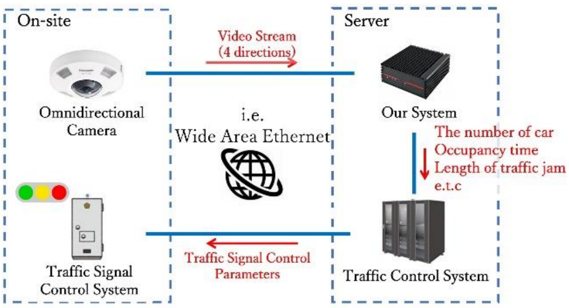

Fig.1 System Structure

Image analysis replace previous vehicle detectors and measure traffic demand that previous vehicle detector’s function. Firstly, captured network camera streaming image datum, secondly image analysis, and last measure traffic demand.

Approach2

Right turn MODERATO control

In situations where right-turn traffic jams occur, AI is used to estimate the right-turn demand based on network camera images, and the estimation results are used as input to generate signal control parameters to actually control the right-turn MODERATO. . By verifying this effect, we will confirm that signal control using image-estimated traffic volume as input contributes to smoothing traffic flow at the intersection.

The goal is to be able to generate a dynamic split according to the right turn demand, and to be able to alleviate the congestion length of vehicles waiting to turn right and the resulting obstruction of vehicles going straight. We refer one intersection which had a problem of congestion at Fig.2

This improvement traffic signal control also confirmed effect for straight lane traffic jam.

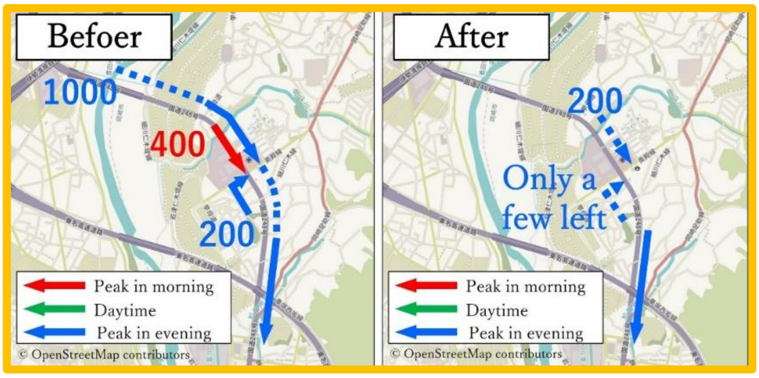

Fig.2 Traffic Jam (Before applying NW-Camera)

***Approach3* measuring number of pedestrians and execute signal control**

Pedestrian green light extension control in situations where there are a large number of pedestrians crossing and it is difficult to cross, AI is used to estimate the number of pedestrians crossing the street based on network camera footage, and the estimation results are used as input to generate signal control parameters, which can then be used in practice.

Pedestrian green lights will be extended. By verifying this effect, we will confirm that signal control using image-estimated traffic volume as input contributes to smoothing traffic flow at the intersection.

The goal is to be able to generate dynamic splits depending on the presence or absence of pedestrians crossing the street, and to improve the number of people waiting for pedestrians.

We show before and after splitting alternative change at Fig.3 and after traffic signal execution result at Fig.4

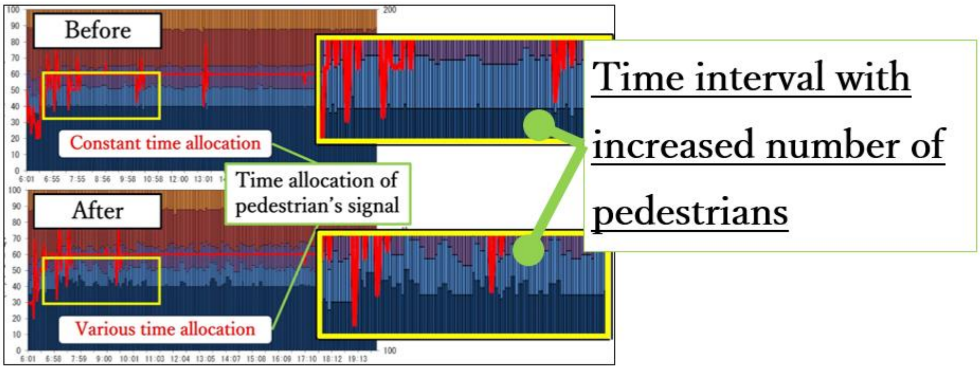

Fig.3 Traffic execution alternative sprit time

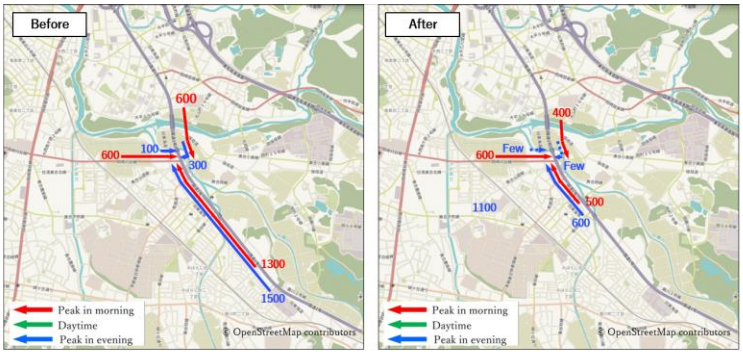

Fig.4 Traffic Jam at Another point (Before applying NW-Camera)

Result

a) We achieved decreasing vehicle detective sensors.

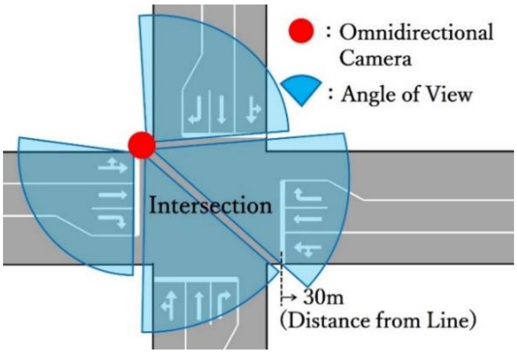

Fig.5 Decrease the number of devices and corresponding cost

b) Enable to detect pedestrians and use this information to apply traffic signal control.

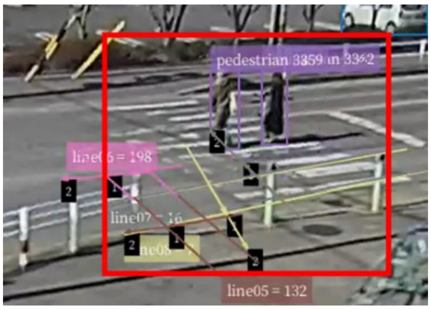

Fig.6 Detect pedestrians

c) **Enable to measure on right turn lane**

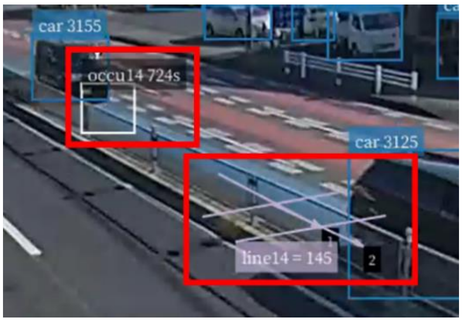

Fig.7 Measure the number of cars and occupancy time on right turn lane

Totally using AI dewarped video drives the result is enabled to cover multi directions with single camera.
Adopting Kalman filter and correlation filter for object tracking drives the result of robust to occlusions.
and improving accuracy and speed even in case of many objects
Using image classification for measuring occupancy time drives the result of robust to halation and small objects.

Future

We show one intersection at Fig.8. This intersection is used as a school route for students, and there are times when there are many pedestrians crossing the intersection resulting in blockages for left-turning vehicles due to pedestrians crossing.
When we measure the effective split under this situation based on on-site footage, we find that the pedestrian side an average of 10 vehicles can make a left turn when there are no pedestrians crossing the road. There are pedestrians crossing.
In this situation, passing vehicles are waiting to turn left, resulting in a loss of 30 seconds and reducing the effective split was found to have decreased to 30%. Additionally, due to the blockage of the left turn lane, vehicles traveling straight ahead were forced to wait.
Through simulation, it was confirmed that by allocating 3 seconds to the PR display split for pedestrians, the number of passing left-turning vehicles increased by 2, and as a result, it was possible to improve the effective split efficiency by 20%. It can be determined that in the future, we will reflect the left turn execution split control on-site, calculate the cumulative number of vehicles from the inflow and outflow traffic flow rates of the left turn lane, and verify the effect on the total delay time.

Fig.8 Turn left problem（stacking）

On this March we estimated and measured left crossing estimation at the same intersection under the nearly same situation (pedestrian crossing intersection and left turn vehicles are stacking).
We want to decrease stacking, so 1PR time would be extending according to the number of left turn vehicles.

ﾌﾙ	1	2	3	4	
(秒)	1PG	1PG	1PW	1PR	1
160	13	44	7	7	
160	13	49	7	8	
160	13	49	7	8	
159	13	46	7	13	
160	13	47	7	13	
160	13	54	7	10	
160	13	54	7	10	

Fig.9 1PR is expanding

Also, in terms of seconds, the time allowed for a left turn across the street was originally 71 seconds, but the time allowed for a left turn is now 7 seconds. The effective left turn travel rate is 7÷71=9.8%.
With this improvement, the 40 seconds of lost time waiting for a left turn has been extended to a maximum of 13 seconds. The effective left-turn travel rate improved to 13 ÷ 79 = 16.4%, allowing 5 vehicles to pass.
We will have an achievement of applying traffic field of Japan's Prefecture. We had a conclusion that the use of network cameras can reduce traffic congestion due to detect right turn jam length, and that pedestrians and motorcycles can safety cross intersection by the appropriate signal control (Pedestrian Green time optimization) .

It was also confirmed that 5G communication can utilize large-capacity, low-latency lines. However, the effectiveness of the method of this demonstration experiment was confirmed only in a limited numerical experiment. We will build a transmission method according to the network bandwidth in the future. Developing network camera transmission technology that stabilizes communication in the optimum band. Increasing the recognition rate by utilizing AI image recognition technology for recognition of the number of stuck people and people riding bicycles, as well as object detection such as motorcycles. We will aim to realize safe and secure intersections without accidents. In addition, we utilized a 4K camera by utilizing a high-speed, low latency 5G line. We will seek to create a mechanism for automatically recognizing accident events. Further edge computerization with one network camera by combination with traffic signal, various sensors, and 5G roadside machines. We would like to contribute to establishment of a safe and secure ITS world by having both vehicles and pedestrians make risk judgments.

References

[1]S.Niikura and Y.Takayanagi "A STUDY OF OPTIMAL ALLOCATION OF DETECTORS FOR TRAFIIC SIGNAL CONTROL SYSTEM" ITS Tokyo,2013

[2]Y.Takayanagi "A STUDY OF APPLYING OPTIMAL DATA ACCUMULATION FOR BIG DATA" (TS33-1768 ITS BOLDO, 2015)