A FAR INFRARED VEHICLE SENSOR FOR A TRAFFIC SIGNAL CONTROL

Koji Hayama, Toshio Minakata
ITS Development Department, Sumitomo Electric Industries, Ltd.
1-1-3 Shimaya, Konohana-ku, Osaka, 554-0024 Japan
Phone: +81-6-6466-8287, Fax: +81-6-6466-5727
E-mail: hayama-kouji@sei.co.jp, minakata-toshio@sei.co.jp

ABSTRACT

Our far infrared vehicle sensor system is a novel vehicle detector that detects vehicles based on temperature differences. Consuming less electrical power, it can be powered by a solar cell battery. Also, it can detect vehicles from oblique directions, and therefore it can be mounted on a shorter mounted arm and is more aesthetically acceptable. Our far infrared vehicle sensor is used for a profile traffic signal control system (a model project of a real-time traffic signal control system) in Kanagawa prefecture and Ehime prefecture, Japan.

KEYWORDS

far infrared, vehicle sensor, real-time traffic signal control, profile traffic signal control

INTRODUCTION

Sensors for detecting vehicles play an important role in traffic control as they are used to acquire traffic jam information and control traffic signals. Some other vehicle sensor systems (e.g. ultrasonic sensor systems, image sensor systems) have been developed and employed according to their intended applications (See Table 1). Any vehicle sensor will required high accuracy, a low price, a high installation flexibility, and contribute to aesthetic preservation after installation. To satisfy these needs, Sumitomo Electric has developed a vehicle sensor that is comprised of a far infrared receiver element called a “thermopile”. This paper describes a development of a far infrared vehicle sensor and application for a traffic signal control.
Table 1: Vehicle sensor systems

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of lanes scanned by one sensor unit</th>
<th>Features</th>
<th>Location of installation</th>
<th>Electric power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic sensor system</td>
<td>Number of vehicles, Occupancy</td>
<td>1 lane</td>
<td>Many examples of good performance</td>
<td>Directly above the target lane</td>
</tr>
<tr>
<td>Image sensor system</td>
<td>Number of vehicles, Occupancy, Velocity, Length of jam</td>
<td>2 to 4 lanes</td>
<td>Multiple functions</td>
<td>Middle of the group of target lanes</td>
</tr>
<tr>
<td>Far infrared sensor system</td>
<td>Number of vehicles, Occupancy</td>
<td>1 lane</td>
<td>Extremely lower power consumption</td>
<td>Obliquely above the target lane (esthetic preservation)</td>
</tr>
</tbody>
</table>

THE PRINCIPLE OF A FAR INFRARED VEHICLE SENSOR

In our far infrared vehicle sensor, the thermopile element is used as a sensor which detects the temperature of the object situated within a sensing area. This element generates thermo-electromotive force which is dependent on the temperature.

Generally, there is the temperature difference between the vehicle and road surface because of the following two factors:

- Difference in thermal absorption and thermal capacity between a vehicle and the road surface.
- Heat emission from a vehicle; especially from its engine or tires.

So, the electromotive force changes when vehicles pass through a sensing area. Our sensor system processes the change by an original algorithm, and detects the existence of vehicles.

STRUCTURE OF OUR FAR INFRARED VEHICLE SENSOR SYSTEM

Fig. 1 illustrates an example of installing our far infrared vehicle sensor system. Our sensor system has the following features.

- Two sensor units can be operated by one battery maintenance unit.
- Sensor units are installed at the roadside or above a line, and can detect vehicles from oblique directions (See Fig. 1).
- There are three kinds of radio data transmission units; a master unit, a slave unit,
and a relay unit. Fig. 1 shows the composition in the case of a slave unit. A slave unit transmits signals of the results of vehicle detection, and a master unit receives them. Transmission distance can be extended by using a relay unit between a master unit and a slave unit.

- Since sensor units and a radio data transmission unit are very low power consumption, our whole sensor system can be operated by a small solar panel.
- The electric power generated with the solar panel is stored in a battery maintenance unit.

![Diagram](image)

**Fig. 1: Structure of our far infrared vehicle sensor**

**THE ADVANCEGE OF A FAR INFRARED VEHICLE SENSOR SYSTEM**

There are some advantages in our far infrared vehicle sensor system compared with other sensor systems. The advantage of our sensor system is described below quantitatively.

**Wireless Transfer Function**

Our sensor system has a function to transmit the vehicles detection signals on radio. Although transmission distance is 200m, it is possible to extend to 400m by using a relay unit between a master unit and a slave unit. Because of wireless transfer function, our sensor system doesn’t need wire to transfer the results of detection.
**Low Electric Power Consumption**

The power consumption of our sensor system (including 2 sensor units and 1 radio unit) is only 50mW, 1/100 of ultrasonic vehicle sensors (See Table 1)

Operating by a solar panel, our sensor system doesn’t need to install power supply wire. Moreover, since signal wire is also unnecessary because of wireless transfer function, our sensor system can be installed without any wire. From these features, improvement in construction workability and reduction of construction cost are realized.

**The Load Side Installation**

Our far infrared vehicle sensor is only a passive sensor which receives the far infrared rays which objects emit. Thus, the installation angle of a sensor has little restriction. Therefore, when we need to detect vehicles of only one lane, our sensor can be directly installed on the pole at the roadside. For this reason, our sensor system has an advantage that an arm is unnecessary.

Moreover, even when installing in the road of two lanes, our sensor system has an advantage that the arm length is shorter than the arm length of other sensor systems (1.5m-2m shorter).

**APPLICATION FOR A TRAFFIC SIGNAL CONTROL**

**About A Profile Traffic Signal Control**

In the conventional traffic signal control system, usually the past data is used for controlling signals. Therefore, when traffic is changing rapidly, the delay of feedback of the data is serious, as a result the control can not be optimal.

In a profile signal control system, not only the traffic information acquired from the vehicle sensors installed on the upstream side of an intersection, but also the information of duration of traffic signals of adjacent intersections is considered to calculate the amount of vehicles flowing out from the intersection. This forecast information is called “profile information”, and is exchanged with each other by traffic signal controllers of intersections. In this way, the number of vehicles arriving into each intersection can be predicted without time lag.

With a profile signal control system, traffic signals can be controlled optimally even in the
area where traffic situation changes sharply according to the time or the day of the week. This system is now operated as a model project in Japan as below, and it is expected to reduce traffic congestion.

**Application of A Far Infrared Sensor Systems for A Profile Traffic Signal Control**

The model project of the profile traffic signal control system was started in April, 2007 in Yokohama city, Kanagawa prefecture (43 crossings) and Matsuyama city, Ehime prefecture (15 crossings).

This system comprises of the central computers and terminal units, and terminal units consist of traffic signal controllers and vehicle sensors. Our far infrared vehicle sensor systems were adopted because of the simplicity of installation and aesthetic preservation. Fig. 2 shows the location of vehicle sensors in Matsuyama city. Vehicle sensors are installed on the road upstream side of each intersection, which collect traffic information such as the number of vehicles arriving to the intersection. There are 76 vehicle sensors used for the profile traffic signal control system in Matsuyama city, and 73 of them are our far infrared vehicle sensors shown in Fig. 2 as black triangles.

16 months have passed since the implementation of the profile signal control system in April 2007. Compared with the conventional system, Effect evaluation has shown that the travel time was shortened about 20% on average.

**CONCLUSION**

We have developed a decent infrared vehicle sensor system with radio communication units which can realize an easy installation and low power consumption. Our vehicle sensor systems are used in a profile traffic signal control system which achieves real-time signal control. Shortening of travel time was proved as a result of effect evaluation of this profile traffic signal control system.
Fig. 2: Vehicle sensors location for the profile traffic signal control system (Matsuyama city)