SENSING OF VEHICLES RUNNING ON PLURAL LANES WITH AN ARTIFICIAL RETINA VEHICLE SENSOR

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１．Introduction

Traffic sensors for use in snowy areas need special capability. Road conditions change so much in areas with heavy snowfall as the seasons change from summer to winter. It is very difficult to produce sensors which remain unaffected by such change. The UC image vehicle sensor is able to monitor the number of vehicles and the occupancy rate (that is the proportion of time with vehicles on the road during a specified period) on roads. Sensors which use a spot detection area are sometimes unable to detect vehicles running along the middle of a two-lane road. In ordinary areas, drivers cross center lines to pass parked vehicles or to overtake other vehicles. In snowy areas, however, people are often forced to drive near the center line because nearside lanes are restricted by snow heaped up after snow clearance, and this causes large errors. The UC image vehicle sensor uses the detection area to determine the timing of the output, and the entire visual field of 8 x 8 meters is used to detect vehicles. This means that all vehicles are detected regardless of the part of the road that they are on.

The results of the following three assessments of two-lane roads are described here.

・The assessment of a sensor for one direction with the detection area set to a spot.
・The assessment of a sensor for one direction with the detection area set to a belt shape.
・The assessment of a sensor for both directions with the direction identified.

2. The UC image vehicle sensor

The UC image vehicle sensor has two major parts: a camera and a controller, as shown in Figure 1. The camera incorporates an artificial retina LSI (an “AR chip”) and the controller includes a DSP for high-speed operation. The AR chip is a CMOS monochrome image sensor with image operation and analog adjustment functions. CMOS sensors consume less electricity and are less expensive than CCD sensors. The AR chip has temporary image processing functions such as filter control, edge detection, negative and positive reversal control and pattern matching. Images are output as a symmetrical analog signal. A circuit can be set up simply because image output can be developed in frame memory just by A/D conversion. Parts such as an iris are not required, because light intensity is controlled by the frame rate, so the sensor is very durable and the whole device is compact.

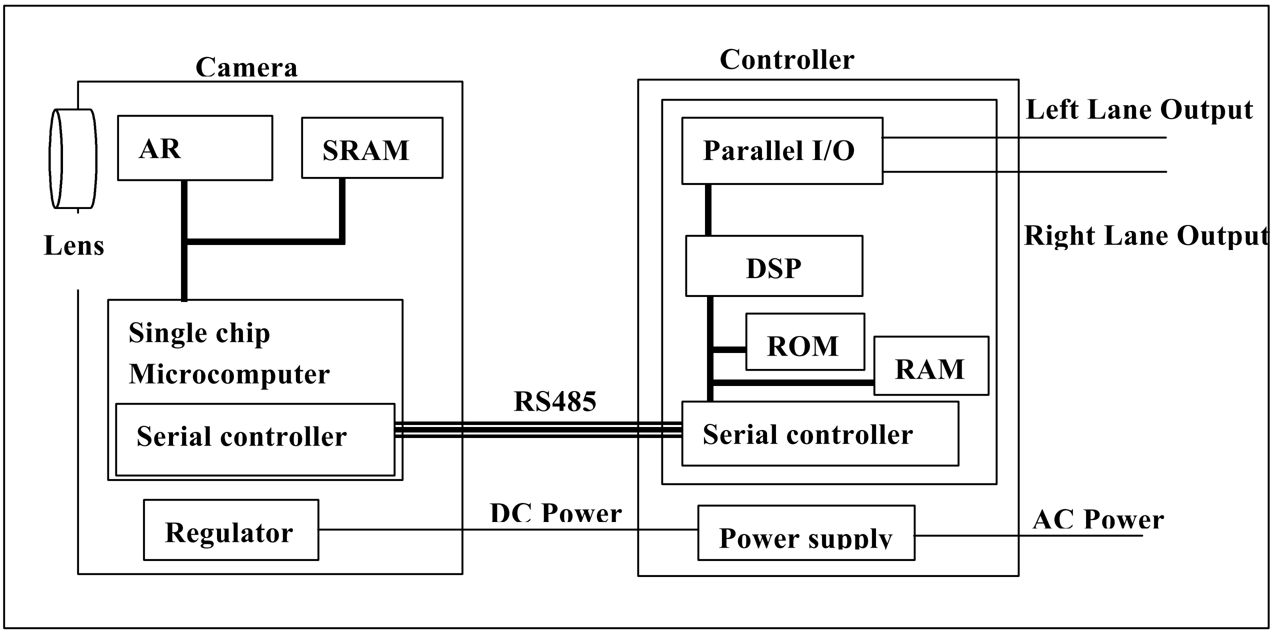

Figure 1 :UC image vehicle sensor

Figure 2 shows an example of a UC image vehicle sensor installed. The sensor camera is installed above the center of two lanes at a height of 5.5 meters. The camera is capable of monitoring vehicles in both lanes. The sensor can be set to monitor one direction or two directions and to exclude motorbikes, etc. The sensor is able to monitor vehicle speeds up to 120km/h.

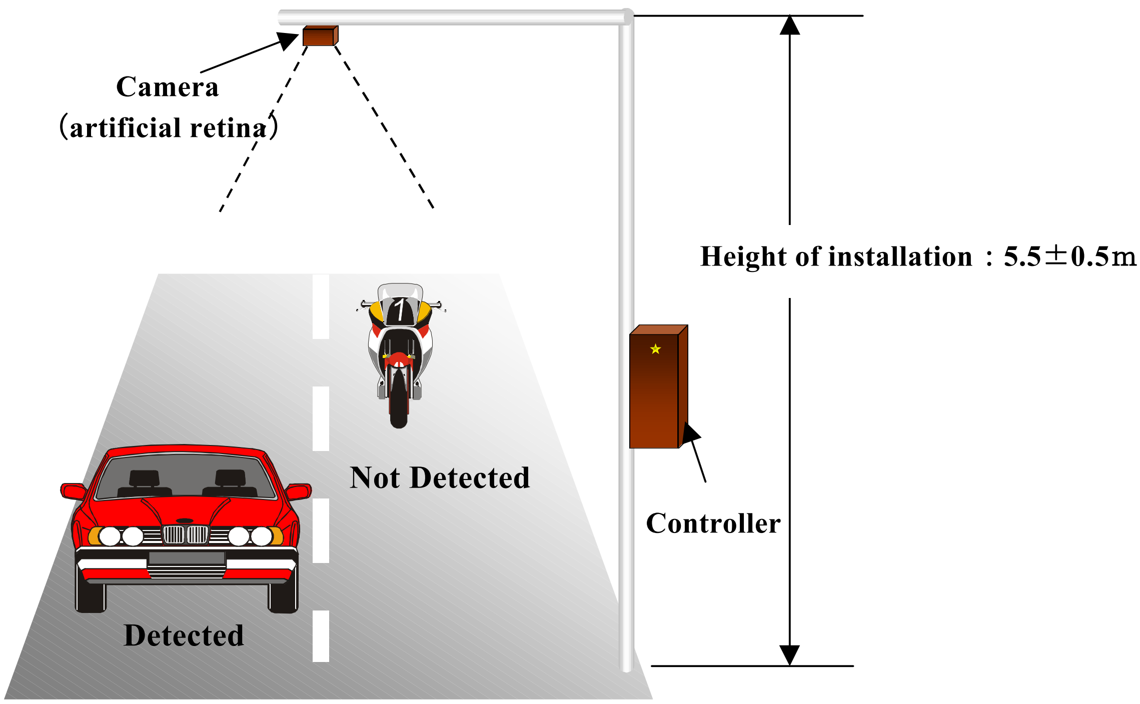

Figure 2 :Example of the UC image vehicle sensor installed

3. Assessment test

3.1 Vehicle detection algorithm

Images taken outside are easily affected by changes in the light. Also, the technology to identify images, including the segregation of identified objects and the identification by shape, is complex. However, it is possible to determine the estimated vehicle domain by using a "prediction method". This method indicates limit conditions gained from constituents and fittings unique to vehicles.

It is desirable to estimate the vehicle domain by using the entire image visual field of approximately 8 x 8 meters. To reduce the time required for identification while maintaining high accuracy of identification, the sensor establishes a virtual area and abstracts the constituents of each vehicle. Then the final vehicle domain is determined by judging the vehicle constituents comprehensively.

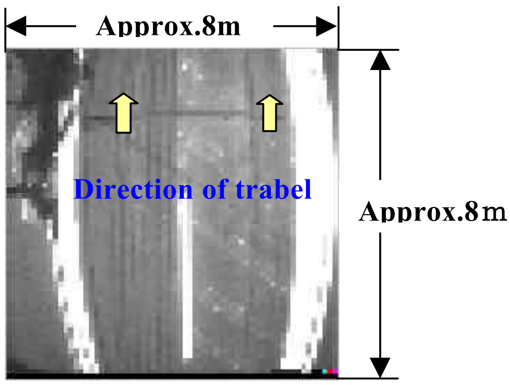

Figure 3: AR sensor image

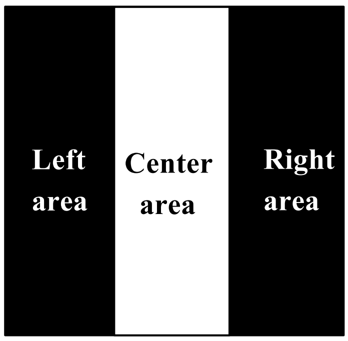

Figure 4 :Virtual area setting

Figure 3 shows an image taken by a camera with an artificial retina set at a height of 5.7 meters. One lane is on the left and the other on the right, and vehicles are moving in the same direction on both lanes.

The image from the camera is divided into three areas as shown in Figure 4. The constituents of vehicles are abstracted in each of the areas. The estimated vehicle domain shows the area from which the characteristics of vehicles are abstracted. The final vehicle domain is determined by judging the size, speed and state transition comprehensively.

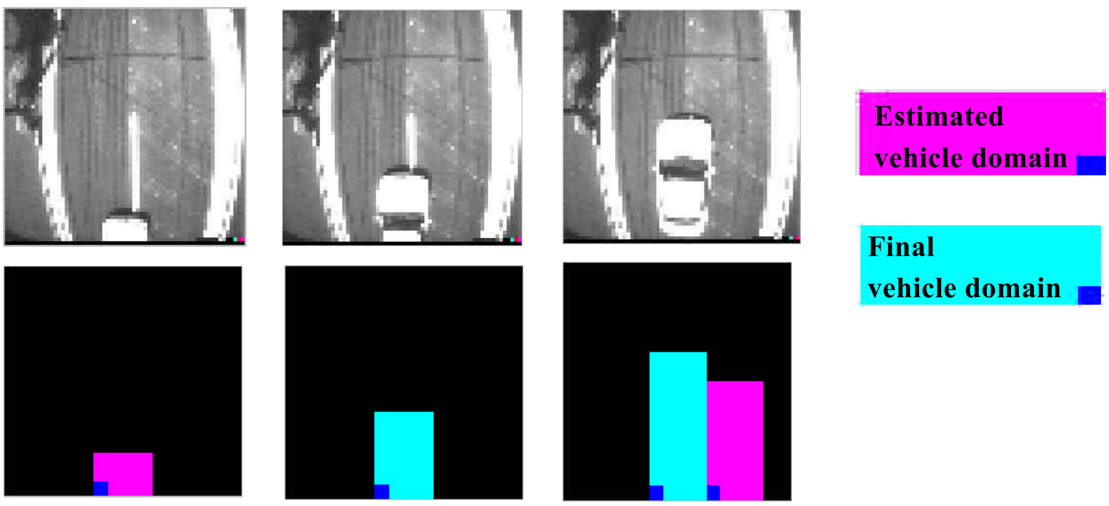

Figure 5 :Vehicle on the road and identification image

3.2Assessment of a sensor with the detection area set to spots

Figure 6 shows images taken by a sensor with the detection area set to approximately 1.2 meter at the center of each lane. Table 1 shows the number of cars counted when the final vehicle domain in three areas shown in Figure 4 enters the detection area.

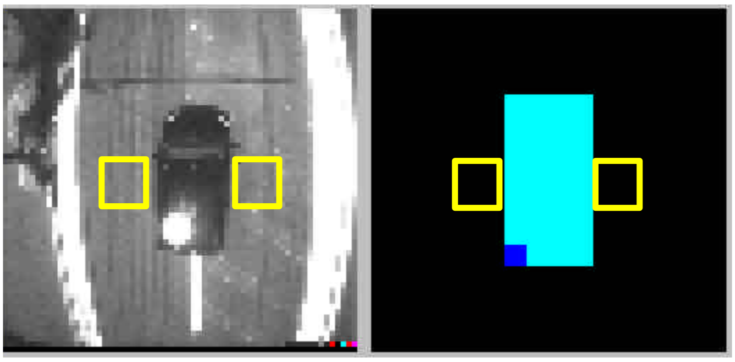

Figure 6 :Detection area setting

Table 1 : Results of identification

	Total	Driving in the middle of the lane	Driving over the lane separation marker
Number of vehicles passed	393	293	100
Number of vehicles accurately identified	331	289	42
Rate of correct identification	**84.2%**	98.6%	**42%**

As shown in Table 1, the proportion of vehicles in the lane correctly identified was 98.6%, while that for vehicles driving over the lane separation marker was 42%. The overall rate of correct identification was reduced because 58 vehicles were not identified as being vehicles.

3.3Assessment of a sensor with the detection area set to a belt shape.

Table 2 shows the result of identification by a sensor with the detection area set to a belt shape around the center of the images. Detection is improved because the detection area is widened to count vehicles in the center area as shown in Figure 4.

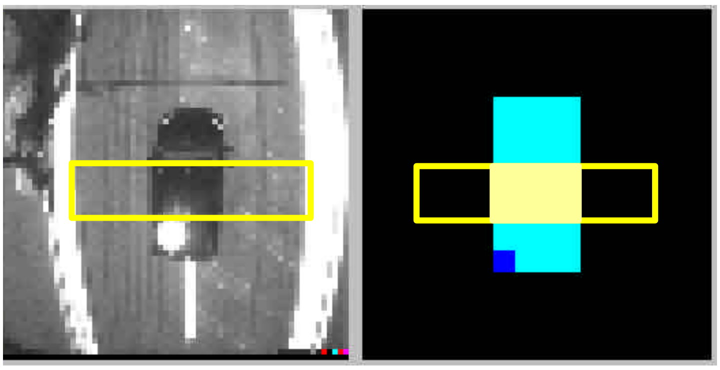

Figure7 :Detection area setting2

Table2:Results of identification

	Total	Driving in the middle of the lane	Driving over the lane separation marker
Number of vehicles passed	393	293	100
Number of vehicles accurately identified	380	282	98
Rate of correct identification	**96.6%**	96.2%	**98%**

When the detection area was set to a belt shape, the rate of correct identification of vehicles driving over the lane separation marker significantly increased from 42% to 98%. Consequently, the overall rate of correct identification raised from 84.2% to 96.6%.

4. Example of applications (identification of direction of vehicles in two lanes)

One of the advantages of image processing is the fact that vehicles are identified as blocks. It has been confirmed that the sensor is able to identify vehicles regardless of the part of the road that the vehicles are on by identifying vehicles as blocks, as described in Item (3-3). However, when a sensor monitors two lanes with vehicles traveling in different directions, the sensor is unable to determine whether vehicles that crossed the center line were part of the traffic flow in the left lane or the right lane. If the direction is identified, the sensor is able to judge the direction of travel of these vehicles and include them in the correct lane.

Figure 8 shows an image of a white vehicle passing over the center line traveling towards the top. A car is parked ahead on the left [the parked car is not shown in the image] and so the moving car passes over the center line. The final vehicle domain gained from identification processing is shown under the images.

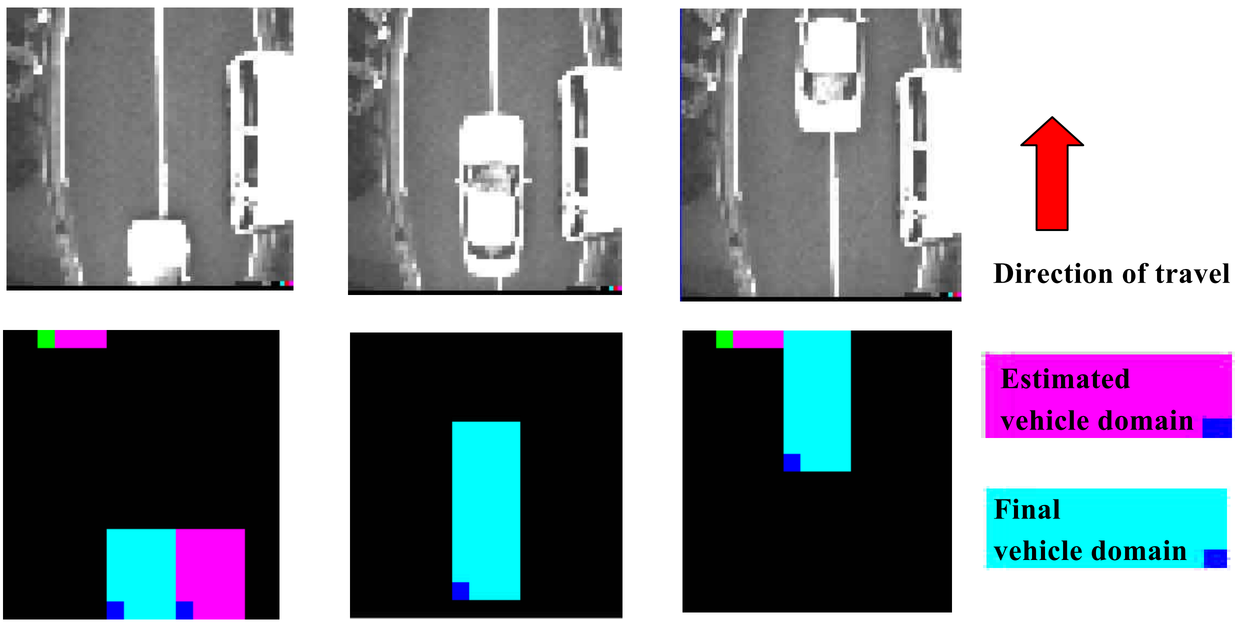

Figure8: White car moving from bottom to top

Figure 9 shows a black car moving over the center line to avoid the car parked on the right. Compared with the images in Figure 8, both cars seem to be moving in the same lane except that the direction of travel is different.

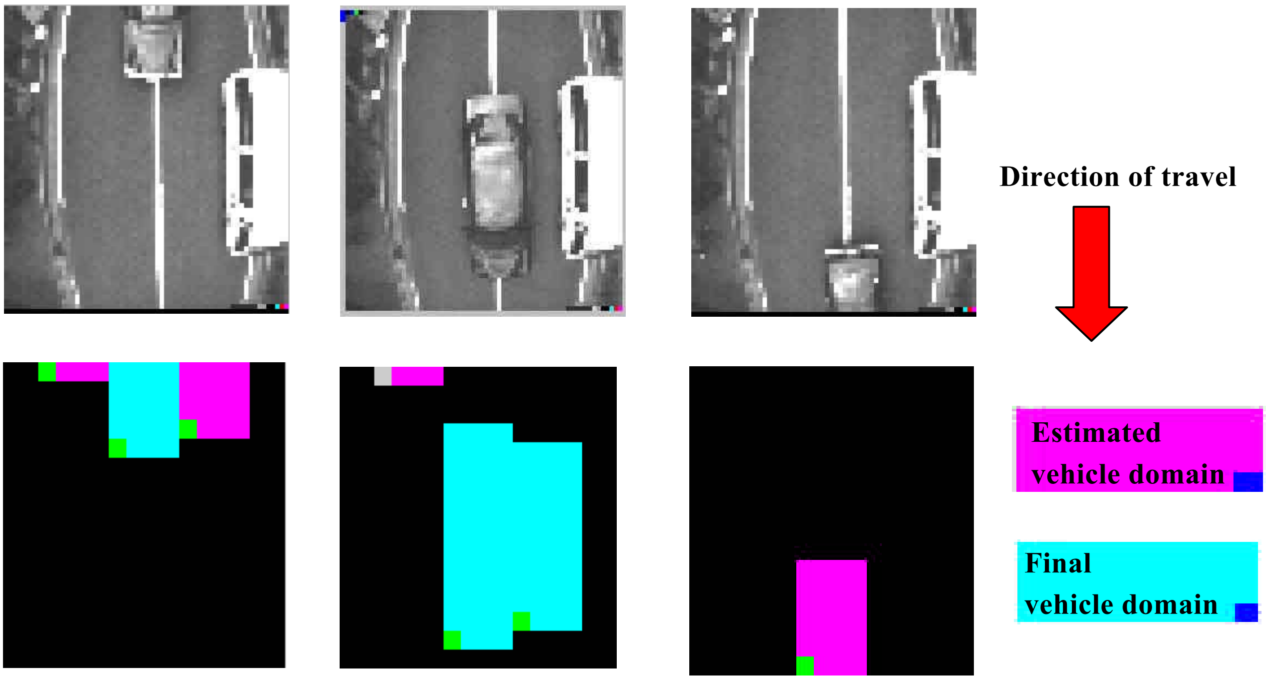

Figure 9: Black car moving from top to bottom

Table 3 shows the results of monitoring 100 vehicles which passed over the center line traveling in both directions.

Table3 :Results of identification

	Total	Driving on the left	Driving on the right
Number of vehicles passed	266	134	132
Number of vehicles accurately identified	252	121	131
Rate of correct identification	**94.7%**	90.2%	99.2%

Table 3 shows that the rate of correct identification of vehicles driven on the right is 99.2%, and that one for vehicles driven on the left is lower at 90.2%. Because there were more vehicles parked on the left, images contained many constituents of vehicles which led to an increase in noise on the left lane and resulted in a lower correct identification rate. The overall rate of correct identification was 94.7% and the assessment showed that direction identification is effective in monitoring two lanes with flows in different directions.

5. Conclusion

・Succeeded in more flexible identification of vehicles using image identification.
・Highly accurate vehicle detection is possible by implementation of direction identification.

Flexible setting of detection area using image identification enables accurate monitoring of vehicles on roads in areas with a lot of snowfall. This type of sensor is particularly effective for narrow, two-lane roads in shopping areas, etc. Many vehicles are usually parked for short times in shopping areas because drivers park to deliver goods or to go shopping. In such areas, many vehicles pass over the center line to avoid parked vehicles. By adding direction identification capability to the sensor, the sensor is able to count vehicles traveling in different directions correctly. The image sensor will not mistakenly count people in the detection area as vehicles.

6. Problems to be solved

The sensor has improved identification accuracy of vehicles in multiple traffic lanes by expanding the detection area from "point" to "line" and "line" to "block" in the identification process. We believe that this result is realized by 2D identification. In the future, development of applications from the 2D identification to 3D identification will be required, not only to further enhance identification accuracy, but also to enable right turn monitoring and cross section traffic monitoring, etc., using image processing.