God's Eye View for Vehicle System

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***Abstract*—Nowadays when the traffic flow is heavy, the driver's view is obscured by preceding vehicles so that drivers cannot see the traffic condition ahead clearly. In that case, it is hard for the driver to overtake the preceding vehicles and even caused the traffic accidents. On the other hand, drivers do not know whether the traffic is congested so that when they realize that the traffic is congested, they are not allowed to do something that driving to other road to eschew traffic congestion. Thus we design a God's Eye View (GEV) system. In GEV, we use two mobile phones as carriers. The system recovers the traffic condition on our mobile phone' screen or Pad according to detect preceding vehicles and sharing the data among vehicles of the Data Tree structure (it is similar to the tree-structure). Using GEV, drivers could know the traffic condition ahead of them so that they can overtake more easily. On the other hand, if drivers can "see" the traffic condition around 1 kilometer ahead of them, they can choose another road to prevent the traffic congestion.**

I. Introduction

With the development of the vehicle network and the vehicle system, functions of them are various (e.g.. GPS and MP3). Owing to different manufactories, however, different product could not communicate with the other so that they cannot share their data or offer the traffic condition to drivers. On the other hand, the vehicle system is expensive, from hundreds of dollars to thousands of dollars. Therefore, it is unrealistic to equip vehicle system for every vehicle.

Otherwise, for supporting the recovering traffic condition function, people may use GPS to meet that naturally. Nevertheless, the non-negligible problem is that every vehicle is required to send the data to a data center so that the data center calculates all the data and feedback to vehicles. It means that the real time will be reduced, since the data center need to process a large amount of data and the delay could not be neglected. Similarly, the robustness will also be affected.

Therefore, GEV is a distributed network. It means that the data center is unnecessary. The vehicle network will be built randomly and additional vehicles could access the network freely. These vehicles could share their personal data with each other in a relatively small range so that GEV can recover the traffic condition in real time. If the network is collapsed, they can rebuild a network easily and immediately.

We also note that the use of mobile phone has ballooned. If we achieve the vehicle system on mobile phone, recovering the traffic condition of data sharing will become possible.

Thus, we design the GEV on android system and achieved these functions:

- Using the mobile phone's camera to detect preceding vehicles and record the information of those of location and velocity.
- Base on the Ad-Hoc mode, transmitting the information (including its own information and other vehicles' information) to neighbor vehicles.
- Recovering the traffic condition on the mobile phone's screen.

The challenges of this system are as follows:

- When the recognizing is interfered by environment (e.g., sunlight), chances are that the mobile phone could not recognize preceding vehicles so that the accuracy would be lowered.
- If the mobile phone cannot match the information received from other vehicles and the transmitter, it could not recover the traffic condition precisely.
- If some vehicles do not have GEV deployed, then it may cause confusion as such vehicles can be viewed by other vehicles but other

vehicles cannot see the traffic condition ahead of such vehicles.

This paper makes the following contributions:

- Using the image processing, the mobile phone could detect a fan-shaped area around 120 degrees and 50 meters ahead of itself.
- Collecting features of vehicles (e.g., the lane number, velocity and the vehicles' color), the mobile phone could match the information and the transmitter precisely.
- Recovering the traffic condition

II. System Overview

The minimum hardware requirement of GEV includes at least two mobile phones. We use two cameras to identify the vehicles and the Wi-Fi function to transmit the traffic data. GEV work flow is as follow:

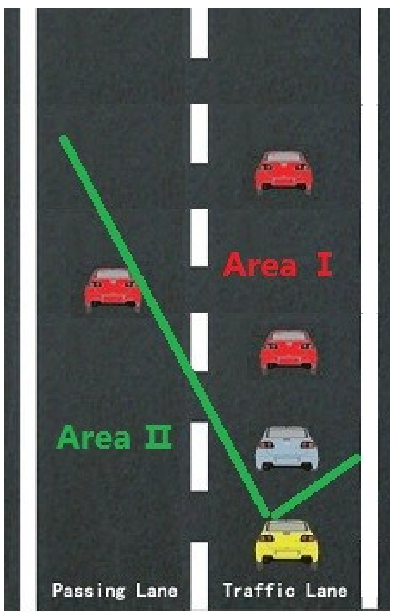

Fig. 1. System Overview

In the figure 1, we assume that we drive the yellow vehicle and the blue vehicle is located in front of us. Therefore, the blue vehicle blocks our view so that we can see the Area II but cannot see the Area I. Thus, for the blue vehicle, it should recognize the traffic condition of Area I and transmit the traffic data to the yellow vehicle. For the yellow vehicle, it also is required to recognize vehicles. After receiving this traffic data, it should match the information of the vehicle features in the traffic data and the vehicles recognized by itself. If matching successfully, GEV will recover the traffic condition on the mobile phone screen.

In the following, we will mainly consider the methods of recognizing and matching.

III. Vehicle Recognition

In various papers, the methods of vehicle recognition are only detecting vehicles that are in front of drivers. Nevertheless, in GEV, the vehicle system will detect a fan-shaped area around 120 degrees ahead of the drivers. In order to achieve that, the system uses two cameras (or two mobile phones) to stimulate the human eyes, and obtain the position, velocity and other features of the vehicle more precisely. We use two algorithms to achieve the vehicle recognition:

1) Shade-edge detection algorithm
2) pixels evaluation algorithm

A. shade-edge detection algorithm

In this algorithm, we use shade detection and edge detection to detect the shadows of vehicles. For every preview frame in the mobile phone, given the interferences (e.g., sunlight) of environment, we transform the image into a grey level image firstly in order to filter interferences. In the following, we set a threshold T. Checking all pixels in the grey level image, if the greyscale of the pixel is greater than the threshold T, I will set this greyscale as 255, it is black. If the greyscale is lower than the threshold T, I will set the greyscale as 0, it is white.

By this time, we get suspicious areas of the shadows of vehicles. However, the image continues to face some interferences, we use the edge detection (canny kernel) to eliminate the noises. Taking the figure 2 as an example, the grey image is like Figure 3. After processing the greyscale of pixels, the image is shown in Figure 4.

B. Pixels evaluation algorithm

In the Figure 5, we set two mobile phones at A and B. l_1 and l_2 are the primary optic axes of the cameras lens. The $\Delta\delta$ is the interval between these two cameras.

Thus, we can determine S and $\Delta\delta$ by these formulas as follow:

$$S = \frac{\Delta\delta \cos\alpha \cos\beta}{\sin(\mid \alpha - \beta \mid)}$$

Fig. 2. Image

Fig. 3. Grey Image

$$\Delta v = \frac{\Delta S}{\Delta t}$$

There is a problem, how to calculate the α and β ?

In order to solve this problem, we issue the Pixels evaluation algorithm. Figure 6 illustrates the method. In this figure, point M is the location of the camera. The line s is the primary optic axis. The brown triangle is the area of view of the camera.

Now assuming that photo 1 (P_1) and photo 2 (P_2) are taken, we can find that the angle $\angle AMs$ is equal to the angle $\angle BMs$. And we know that equation:

$$\frac{a_1 A}{a_1 a_2} = \frac{b_1 B}{b_1 b_2}$$

Thus, the $x - coordinate$ of point A in the P_1 is equal to the point B in the P_2. It means that the

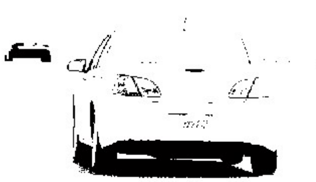

Fig. 4. Result

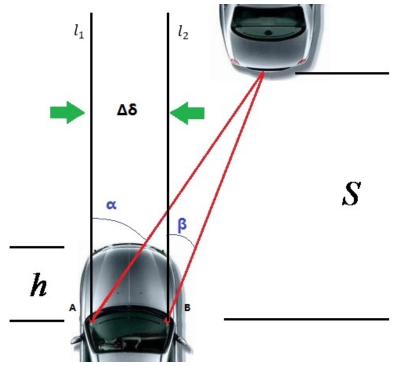

Fig. 5.

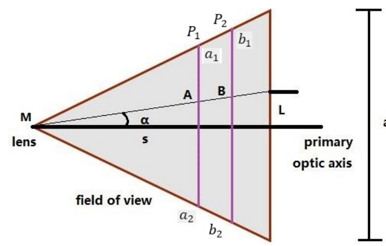

Fig. 6. Pixels evaluation algorithm

Point A and B will have the same angle α. Just like the Figure 7. The point P and Q have the same $x - coordinate$ in their own photo. Therefore the angle between the lens and the primary axis is equal.

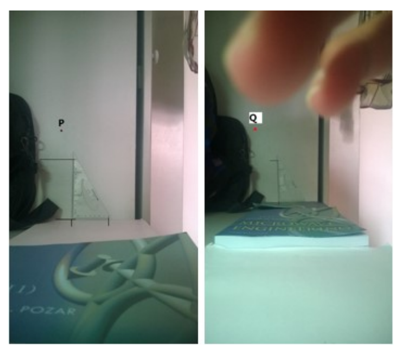

Fig. 7.

IV. Data Transmitting

Actually, the radius of detection area of a vehicle is limited. Hence, each vehicle has to share its own information to other vehicles within a certain range. In the Figure 8, the red circle is the information-shared area of the blue vehicle.

The yellow vehicle will build a connection to the blue vehicle when the yellow vehicle enters

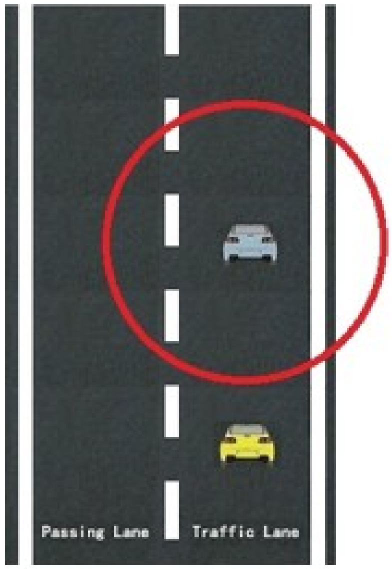

Fig. 8.

the red circle (PSThe red circle is much smaller than the actual range). The connection would not be interrupted until the yellow vehicle leaves the red circle. Nevertheless, if the situation like the Figure 9, it is a problem that how to identify which vehicle is the source of that information?

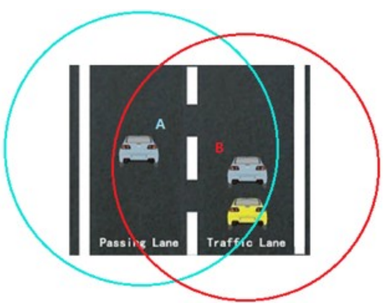

Fig. 9.

Toward this, we will consider some features about the vehicles (e.g., the vehicles color, the plate number, the lane number, the model, the GPS coordinates and the velocity).

We should notice that the features is useful for GEV as long as it satisfies these requirements:

1) It can be known by itself.
2) It can be measured by its neighbor vehicles.
3) It is reliable.

By this way, we can match the vehicle and the data source precisely.

V. Traffic Condition Recovering

Taking the android mobile phone as an example, in the Figure 10, we assume that we are driving the yellow vehicle. The left is the real traffic condition. The mobile phone can determine our location by the GPS as well as the blue vehicle location by the camera. At the same time, it would show these locations on the screen. Since the mobile phone receives the traffic data from blue vehicle, it can calculate the location of two red vehicles according to the distance S, angle φ and other information.

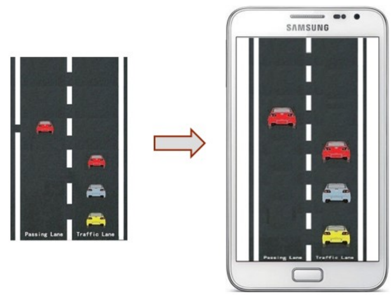

Fig. 10. Recovering

Thus far, the GVE is achieved.

VI. Future Work

There two future works we can do:

1) Intelligent Driving System
   - In this system, it could give drivers some advice about overtaking according to the information of all vehicles that are in front of drivers.
   - Beyond that, the system can also warn drivers. For example, when the vehicle driven by us is too close to other vehicle which is in front of us, the system will warn us.
2) Traffic Flow Control
   If we can "see" places where are far from us, the system could analyze the traffic data, and find an optimal route to the destination. This function is helpful for drivers.