Information Extraction from Traffic Images

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Abstract

This paper discusses information extraction from traffic images. The images have been provided for the monitoring purpose by humans, but we here consider how we can utilise them by automatic monitoring. Algorithms for detecting running cars and the parking cars will be shown.

1 Introduction

In recent traffic systems, it is very popular to provide the traffic information to the drivers by the electric bulletin board on the road and/or radio broadcasting. The main information provided by such systems is the state of traffic jam, the estimated travel time, the condition of parking areas and so on. This is useful on main streets such as highways because such information is useful uniformly to most of the drivers. It is also possible to provide more local information to personal mobile equipment such as mobile phones by request. Thus traffic information using mobile phones will provide synergetic utilities.

The main topics related to this kind of image processing include illuminance processing [1], robustness [4, 2], estimation of background [3].

The group of one of the authors have been developing ATTAIN (Advanced Traffic and Travel Information in Nottingham) system[1] which is a text-message providing system to the mobile phones by entering a request with the origin and the destination codes. The ATTAIN project investigates the principles and practicalities of integration of various traffic and travel information (lane occupancy, bus location, bus timetables, etc.) for the purpose of providing intelligent urban travel advice. Text messaging was the main means for query response system using mobile phones, and it is definitely advantageous in the communication fee for the users. Although Internet access to sites with images by mobile phones is still fairly expensive, it is already very popular for people to do so in Japan, and the users seem to have little cost-consciousness to use them. This will be a good infrastructure for us to provide image information as well as text information of the traffic on demand.

The Nottingham TravelWise Service[2] has been providing various kinds of traffic information including camera images at many points in the city. There are also other sites that provide road images via Internet (*e.g.* a collection of URL is provided at a site[3] and a site[4], and a site to provide road images to mobile phones here[5]).

Most of the sites provide still images that are updated at every minute or so. Some sites provide streaming video images (*e.g.* http://www.jpbdbk.gov.my/eng/), but it is not popular yet.

Therefore, we have been investigating how to utilise the WEB images of Nottingham TravelWise Service from the access of mobile phones.

This paper considers applications of traffic image processing. Unlike conventional loop detectors which are buried in the ground to count the passing vehicles above, image monitoring systems are less disruptive and less costly to install [2].

2 Objectives of Image Processing

2.1 Useful For Control Centre

These images are now being used for the surveillance of the important points of traffic to be shown on the monitor screen, and this work is done by humans.

[1]http://www.doc.ntu.ac.uk/RTTS/Projects/grr32468/public.html

[2]http://www.itsnottingham.info/index.htm
[3]http://www.mars.dti.ne.jp/∼ohtomo/camera.htm
[4]http://www.sekainomado.com/road.html
[5]http://www.avis.ne.jp/∼ chouken/oomachi/

Probably they are monitoring items like traffic accidents, nuisance dropped objects and traffic jams as well as others of these kinds. Hence the objectives of the automatic processing of image processing should include detection of these items. However they are not limited to those above. By the automatic processing, further processing can be developed which humans cannot achieve satisfactorily. The transition of the traffic amount is a good example of this possibility.

2.2 For the Drivers of Private Cars

The images can be useful to the drivers of private cars. A car driver may want to know if there is any traffic jam on the way to his/her destination. It will also be a great help if he/she can know whether there is any roadwork ahead. He/she may be possible to change the route.

For the access to the online information, mobile phones will play a crucial role. In ATTAIN System, the bus service information is available based on the time on the computer and the origin/destination provided by the user. The information is provided via SMS (short message service) of Vodafone where only text messages is available.

For the drivers of private cars, we assume that providing personalised traffic information to people with mobile phones or PDAs with LAN connection is important. To achieve it, the following steps will be necessary.

1. extract linguistic information
2. provide personalised text message and small images with small number of click times by being combined with ATTAIN system.

The following part of this paper focuses on the step 1 of the above items. It should be mentioned that we are also interested in integrating the text message and some small images for this purpose.

The Internet service on mobile phones is already popular in Japan, and will also be the same in other countries in the near future. If the user uses Internet connection, text and image information can be provided simultaneously, and we can provide a sophisticated service by programs both from server side and the client side. However, the images that are possible to be shown on the screen of mobile phones are very small (*e.g.* 120×90 pixels). Also, the connection charge depends on the amount of information. So, it is necessary to provide appropriate information which user really wants to get.

3 Extracting Linguistic Information

3.1 Image Processing for Extracting Cars

The basic process for this system will be to extract cars. Figs. 1 and 2 are consecutive images available for the public via Internet. It is possible to expose images more often, but they don't do so due to the privacy. The interval of the new image acquisition is usually 3-4 minutes or more.

Figure 1. Traffic image at time $t-1$

Figure 2. Traffic image at time t

The fundamental idea is as follows. The difference between the successive frames gives images of the moving objects. However, by this method, the moving object appears twice in the successive difference images. So, we use two-stage difference to obtain the image once.

We define the image processing part of the object detection algortihm as follows:

<u>Image processing algorithm</u>

1. Compute the absolute of the difference df1 by

$$\mathtt{df1} = |\mathtt{NEW} - \mathtt{BACK1}|$$

   where `BACK1` is the one step old image (take the absolute $|\cdot|$ for each element).

2. Get new image `NEW`. Iterate the following part.
   (a) If `NEW` is the same as the previous one, skip the following and wait for the next image.
   (b) Copy `df1` to `df2`.

(c) Compute

$$\texttt{df1} = |\texttt{NEW} - \texttt{BACK1}|$$

(d) Compute ddff by

$$\texttt{ddff} = \texttt{binary}\,(\min(\texttt{df1}, |\texttt{df1} - \texttt{df2}|)) \quad (1)$$

where min operation works on the elements at each position of two image matrices.

(e) Compute the spatial difference image

$$\texttt{sd} = \texttt{binary}\left(\left(\left| \frac{\partial \mathrm{NEW}}{\partial x} \right| + \left| \frac{\partial \mathrm{NEW}}{\partial y} \right| \right) \Big/ 2 \right) \quad (2)$$

(f) Compute the logical AND

$$\texttt{FP} = \texttt{ddff} \cdot \texttt{sd} \quad (3)$$

Fig. 3 shows the binarised image where the threshold was set to 20% from the lowest value in the gray image.

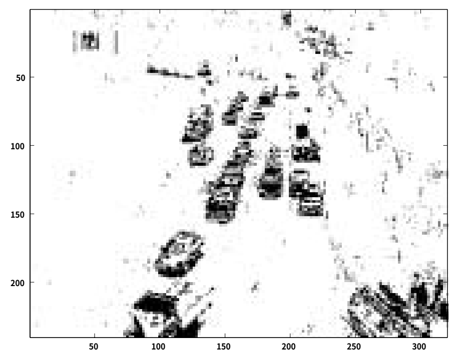

Figure 3. Binarized image

Fig. 4 shows the spatial difference within the current image.

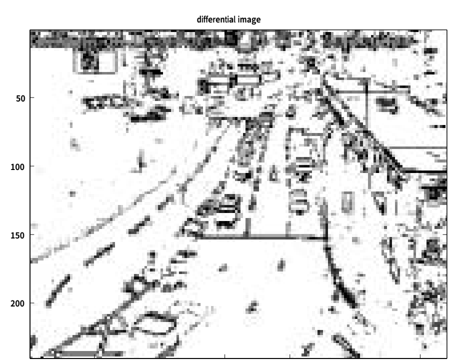

Figure 4. Spatial difference

Fig. 5 shows FP using images Figs. 3 and 4 where the lines separating lanes are added by a different program. We consider this as the final processed image. Note that

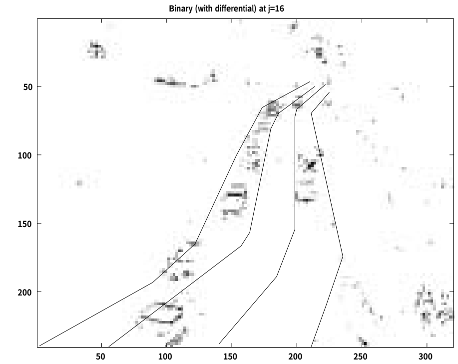

Figure 5. Detection image (normal case)

the black area is where the value is one and the white area is where the value is zero.

Fig. 6 shows another original image at a dark environment when all the cars are using head lights.

Figure 6. Cars with head lights

Fig. 7 shows the processed result for this head light case. We can see that the car detection performance is not much degraded for this case.

3.2 Judgement after Image Processing

Our method is based on the soft assumption that the direction of the road is nearly vertical. If the road is far from vertical, the higher part of the car is measured in the next lane area. Hence we will suffer from the overlapping of the cars in the next lanes. We adopted an easy way to avoid this problem. It is to use the observation data only in the centre part of the lanes. This is also useful if the camera position includes some uncertainty.

Fig. 8 shows the measured area for each lane. For each lane, 1/3 of the width of the lane is measured.

We construct the judgement algorithm here.

Judgement algorithm

1. For each lane, do the following.

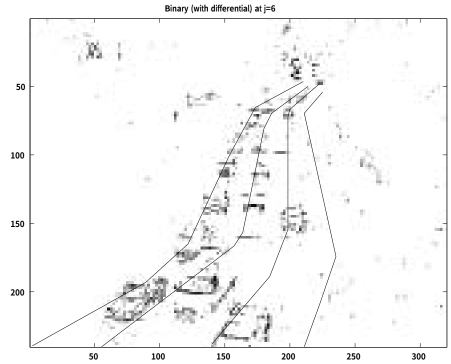

Figure 7. Detection image (head light case)

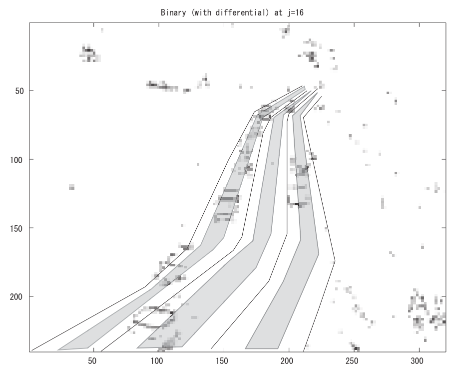

Figure 8. Definition of measuring area for each lane

(a) for each row from top, do the following.

   i. Count the black dots in the shaded area of Fig. 8.

   ii. Compute the proportion of black dots in the shaded area for normalisation.

   Fig. 9 shows the proportion of the detected object for the width of each lane. This figure corresponds to Fig. 5 (normal case). The top sub-figure shows the detected signal in the right lane of Fig. 5. The left of Fig. 9 corresponds to the top of Fig. 5. The second sub-figure corresponds to the center lane, and the third sub-figure corresponds to the left lane, respectively.

(b) Prepare a window of size s (*e.g.* $s = 5$). This window is shifted after processed. In the window, the second largest value is taken as the smoothed value of the centre point.

(c) Scan the smoothed values. If the value is higher than the threshold, we take this point as some object.

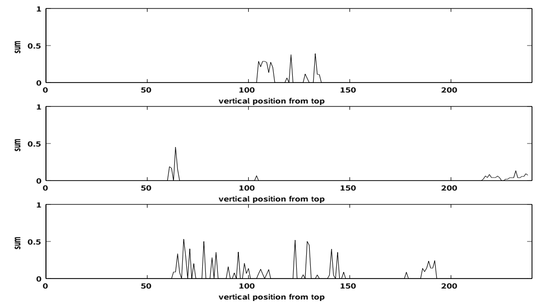

Figure 9. Detected signals for each lane (normal case)

Fig. 10 shows the result for the case of Fig. 6 (head light case).

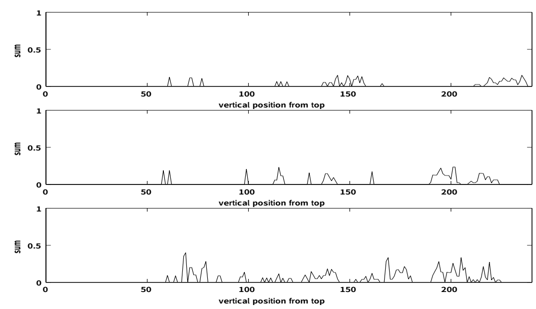

Figure 10. Detected signals for each lane (head light case)

Figure 11 shows the filtered values for the signal in Fig. 9. Figure 12 shows the detected objects indicated by the black bars. Most of the cars have been detected, but some cars are counted twice. This is due to the fact that the observed size of the car is quite different in the near and far place, but the processing method is the same.

3.3 Detection of Parking Cars

We assume that the parking cars can be seen on the current image but they cannot be detected by the above algorithm.

Our algorithm for this purpose consists of two parts: (1) object detection in the current image, and (2) elimination of moving cars.

To detect the objects in the current image, we use Fig. 4 as the `sd` instead of `FP` as the input to the "Judgement algorithm". Thus we get the candidates of the parking cars. Next we eliminate the cars that have already appeared in the car detection algorithm.

The following figures show an example of parking car detection. Figure 14 is the previous image and we can

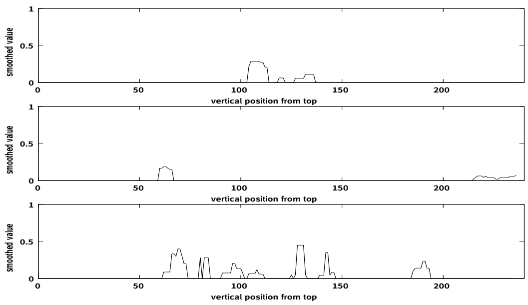

Figure 11. Filtered signals for each lane (normal case)

Figure 12. Detected car regions for the normal case

see the current image in Fig. 15. Figure 15 is the detected cars in the current image by the algorithm proposed in the previous section. Note that parking cars have not been detected in the image.

Figure 16 shows the detected objects obtained from only the spatial difference of the current image at time t. By our algorithm, paking cars are the ones in Fig. 16 where the current cars in Fig. 15 are removed.

Figure 17 shows the detected parking cars by the algorithm we proposed above. In this figure, four objects have been detected as parking cars. The parking car in the left lane has been detected, and another car in the same lane has been recognized as a newly arrival car. A small object in the same lane has been detected, but this is not a car. This error is due to the fact that the lane has been defined to the upper area that is not actually a road. Two objects (one is large and the other is small) in the second right lane have been detected. The long one is an error due to the fact that, although it is not a parking car, another car can been seen on the same place as the one in the previous car, thus it has been detected. A small object in the lower part of the second right lane is a mark of the road.

Figure 13. Detected car regions for the head light case

Figure 14. Image at time $t_1 - 1$

3.4 Detection of Panning

If the camera is panned, the pre-defined lane is useless. So it is necessary to know if panned. Fortunately the image is quite different if the camera is panned, and this difference is completely out of the range of deviation of the moving object in the same scene.

4 Conclusions

In this paper, we discussed how to utilise the traffic images to automatic monitoring. The target system is the ATTAIN System of Nottingham, where the images are provided from ca. 50 cameras.

We are aiming to supply useful information to the mobile phones via Internet. The lateral collaboration of the images in the city will also be useful. The implementation of the system is crucial for actual use.

Acknowledgment

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Figure 15. Detected car regions at t_1

Figure 16. Detected objects by the spatial difference in the current image

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Figure 17. Detected parking cars

Figure 18. Image at time $t_2 - 1$

Figure 19. Image at time t_2

Figure 20. Detected parking cars