VEHICLE DETECTION

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Abstract: This work introduces a complex method for real-time vehicle detection. It is based on analysis of video-sequence acquired from static camera situated on highway. Processing consists of many steps. It starts with a simple background subtraction and end with monitoring results, i.e. average speed, number of cars etc. This paper describes suitable approaches for solving single steps of analysis with respect to time requirements.

Keywords: Vehicle detection, traffic monitoring, video analysis, segmentation

1. INTRODUCTION

Nowadays the term image processing can be encountered in many branches and applications, such as flow line supervision, tomography etc., but also in an everyday life. Another example can be traffic monitoring and its consequent evaluation. That can give very useful information, for example traffic density, possibility of congestions, arrival time to some specific place or road traffic accidents detection. This all can be done without the human intervention. Thanks to many advantages of this approach, development of these systems is progressing really fast.

2. ALGORITHM DESCRIPTION

Vehicle detection in video-sequence is a part of image processing. It introduces the use of methods that are capable of getting relevant information about actual vehicle position or traffic situation in the monitored scene. Main task of proposed algorithm is to get the number of vehicles and their average speed.

For the algorithm to be robust enough it must cope with different light and weather conditions. Therefore it is split to daylight and night mode. Their functionality is described below. Switching between them is made as sudden with hysteresis. The deciding factor is brightness of extracted background of monitored scene.

The diagram of video-sequence processing is shown in Figure 1. The input data here are actually evaluated image and foregoing background of the scene. At first it is necessary to separate foreground mask that represents the basis of detection. It is then used for edge detection and shadow elimination. Section called Object segmentation localizes individual vehicles in image and describes them. This information then advances to final phase where it is compared to the vehicles found in preceding images. The output of algorithm is a motion evaluation in the scene. It is then subject to statistical processing of video-sequence. Important part is also function of background update that continually corrects extracted background and reacts to the changes of environment. Individual blocks of diagram are described below.

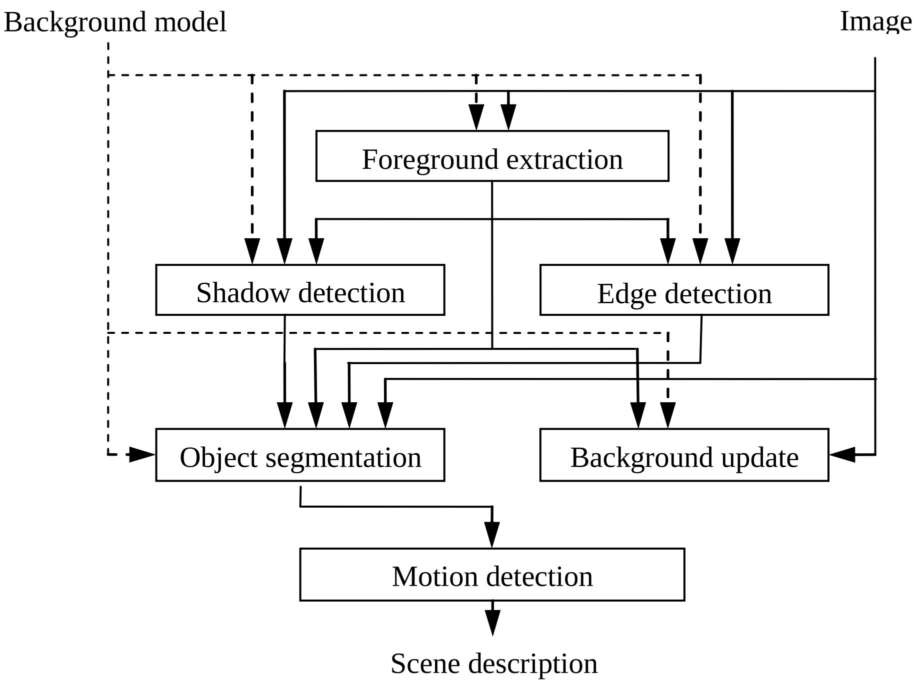


Figure 1: Block diagram of daylight processing

2.1. FOREGROUND EXTRACTION

The basis of method is the extracted background. To get a foreground mask, method of static threshold is used (Chapter 2.2). Due to automatic camera brightness correction or eventual reflections, the overall brightness of image can fairly fluctuate. The proposed algorithm initially uses the inverse thresholding of difference image (absolute value of image and background subtraction) through RGB with relatively high threshold. This way the vehicles in scene are eliminated. Result of this is a mask of ambient that is used for correction evaluation with respect to background. Input image is then corrected and processed by static threshold. It is desirable for this threshold to be smallest possible. Otherwise some vehicles could be ignored because of similarity with background. Result of foreground extraction is shown in Figure 2. Due to low tilt of camera the upper ¼ of mask is ignored. It is because of overlapping vehicles and consequent possible errors in speed evaluation. Furthermore it is affected by environmental processes that are not interesting for detection. Further processing is mainly restricted by foreground mask.


Figure 2: Foreground extraction

2.2. BACKGROUND UPDATE

The headstone of almost all algorithms of moving objects detection is the most precise evaluation of scene background model. Its knowledge can help us with detection of vehicles through sequence. During initialization phase it is necessary to use N images to get an average background. This must be, due to fluctuating weather and light condition, further updated. The most suitable for this task is the use of average deviation as decisive factor. Every point of extracted background is characterized by average brightness and deviation. So the principle is obvious. If the brightness of input image point is inside interval given by background average and deviation, this point is used for update. The suitable method for correction is the exponential floating average (Equation 1). The point of background B_K is adjusted according to coefficient α to I_K.

$$B_{k+1} = \alpha \cdot I_k + (1-\alpha) \cdot B_k, \qquad (1)$$

This solution can very dynamically react to environmental changes. Furthermore it has no additional memory or computational power requirements. When set correctly, this method can cope with much complex method, described in e.g. Piccardi [1].

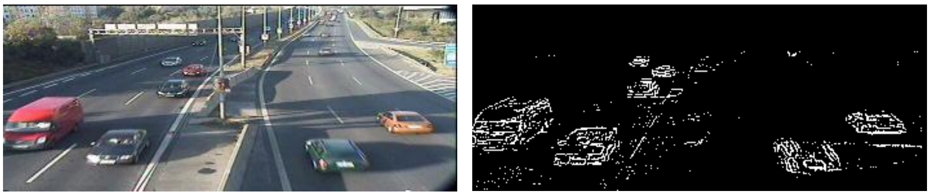
2.3. SHADOW DETECTION

Another part of processing chain is shadow detection. Its presence fairly complicates image segmentation. Moving shadow is, as other objects in the scene, falsely marked as detected object. The main characteristic of shadow is the decrease of brightness in affected area. Further it is so called penumbra at its edge (described in Stauder et al [2]) that originates because the sun is not the point light source. This assumption is only useful with high resolution images. Another very important factor is the relative increase of blue component in affected area. Shadows are mainly blue due to character of sun shine and the use of cameras with automatic white balance. These characteristics are not in fact used for shadow elimination but rather for calculation of shadow presence probability in given area. This information is then used for consequent processing.

Figure 3: Shadow detection

2.4. OBJECT SEGMENTATION

Method used in this work is mainly based on edge detection. It is similar to techniques used in Liu et al [3] or Xiao et al [4]. Input image along with background is processed by edge detection operator. Gradients from both are then compared. In case that they match, we are talking about edges of static objects in background. These are eliminated from further processing. In other case, the gradients belong to dynamic objects (vehicles). However, gradient is also present at the margin of shadow. Here we use the previous information about shadow presence to suppress these false edges.



a) Input image c) Detected edges

c) Detected objects d) Relaxed objects

Figure 4: Process of vehicle detection

After that, dynamic edges are segmented using smoothing operation. As shown in Figure 4, sometimes there are not too many edges in vehicle area. Due to this problem, part of the vehicle could be falsely omitted. To correct this, the proposed algorithm uses kind of relaxation method. It can restore the areas that were eliminated in previous steps. This is very useful for one-color flat surfaces.

2.5. SCENE MONITORING

To create a complex description of happening in scene it is necessary to link information from consecutive images of sequence. So the main task is monitoring of vehicle on its way through the field of sight of camera. To be able to process data in real-time the algorithm must be fast enough. That is why we cannot use the complex methods, such as optical flow. Instead of that, the vehicles detected in partial images are characterized by descriptors. Consequently it is possible to track this vehicle by means of searching for most probable predecessor.

For us to be able to estimate vehicle dimensions and sort it to correct category, it is necessary to know the precise position and orientation of camera. Then we can parametrically describe the scene and get desirable vehicle speed.

Figure 5: Result of daylight mode vehicle detection

2.6. NIGHT MODE

Night mode is based on detection of headlights in images. It is done similarly as in daylight mode by comparison with background model. Particular headlight needs to be paired. This is solved as searching for correspondence based on mutual distance and size of particular headlights. Pairs are then characterized by descriptors and tracked through the scene in a similar way as in daylight mode (Figure 6). Left and right side of image are processed separately considering different light characteristics of front and read lights. Furthermore algorithm must cope with reflections on roadway caused by headlights.

Figure 6: Result of night mode vehicle detection

3. USER INTERFACE

The simple graphic user interface was created for testing purposes of algorithm (Figure 7). It helps to simulate input sequence problems and responses. It also has simple scene settings and necessary algorithm parameters. Finally it presents the results of detection. Both in graphical (Figure 5) and printed statistical output (Figure 7e,f). The most important is the number of vehicles, sorted in two categories. Average speed is computed for particular lanes. These can be either specified in configuration file or automatically detected by algorithm according to vehicle movement.

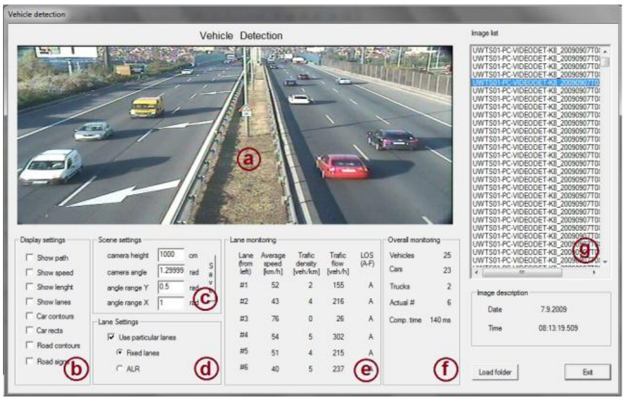


Figure 7: User interface; a) graphic output; b) output settings; c) scene parameters; d) lane settings; e) lane monitoring results; f) overall statistics; g) video-sequence selection

4. RESULTS

For testing purposes about 5000 test images were acquired from static camera situated on highway under variety of weather and light conditions. Resolution of images is 352x144pxls. Accuracy of detection is balancing between 80 and 90 per cent in dependence on conditions. It is very good result when we take into account, that it is possible to evaluate 20 images per second. Tests was performed on processor Intel Pentium Dual Core 2.1 GHz. Assuming 5 images per second from one camera, this algorithm is capable of managing 4 camera sites. Additionally we could gain even more by using multi-threading principle.

5. CONCLUSIONS

Main aim of this work was to create a complex method for vehicle detection in video-sequence. Algorithm shows good analytical results. Thanks to very general approach and emphasis of reliability in real conditions, algorithm is able to provide very useful traffic monitoring data with sufficient accuracy.

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