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IMAGE ANALYZING FOR ADAPTIVE FRONT LIGHTINGS SYSTEM

ZPRACOVÁNÍ OBRAZU PRO SYSTÉM ADAPTIVNÍHO ŘÍZENÍ PŘEDNÍCH SVĚTEL

Abstract

In area of the acquisition of the operating conditions of the car for the detection of wet/dry road, driving in house building, tunnel and rear and front lightings of others vehicles it is possible to use quite a number of the specialized sensors. This article describes detection of operation conditions - mentioned above - entirely by using camera subsystem installed in the car.

Abstrakt

V oblasti získávání dat pro detekci okolních podmínek automobilu, jako je mokrá/ suchá vozovka, jízda v obydlené zástavbě, jízda tunelem, detekce brzdových a čelních světel dalších vozidel je možné použít celé řady specializovaných senzorů. Článek popisuje detekci zmiňovaných stavů pomocí kamerového subsystému instalovaného na vozidle.

Keywords: Road Condition, Automotive, Image Processing, Adaptive Front lightings Systems, AFS

1 INTRODUCTION

Extension of vehicles and facilities in the 20th and in beginning of the 21st century has brought high mobility, economic and industrial prosperity. Automobile transport has also created serious problems such as rising annual traffic accidents and environmental degradation due to traffic jam and concentration. Some car manufacturers have implemented into luxury cars new intelligent driver assistance subsystems which increase safety and comfort of the passengers and transport. They are e.g. automatic parking system, automatic limiting speed of car by traffic signs – with help of image recognition subsystem, traffic lane markers detecting, inter-vehicle distances, detecting wet surface of a road, detecting obstacles, detecting driver's micro sleep, automatic switching and positioning lights under actual operating conditions. This conditions can be speed and presence of car in house building, fog, tunnel entrance, overtaking car (at night) etc. Some of these detected conditions begin to be implemented into cars of the middle class. The aim is to achieve a significant increase in road safety inclusive of driving comfort and increased competitiveness.

2 REAR AND FRONT LIGHTS

The detecting of rear and front lights of surrounding vehicles during nighttime is possible to use for automatic switching between low and high bending (lower lights, distance lights) – *Adaptive Front lightings Systems (AFS)*. The aim is to give reliable information about overtaking or incoming vehicles and adjust actual state of own lights. The system uses color camera signal. The raw signal is first preprocessed and only its middle part is used next - Fig. 1.

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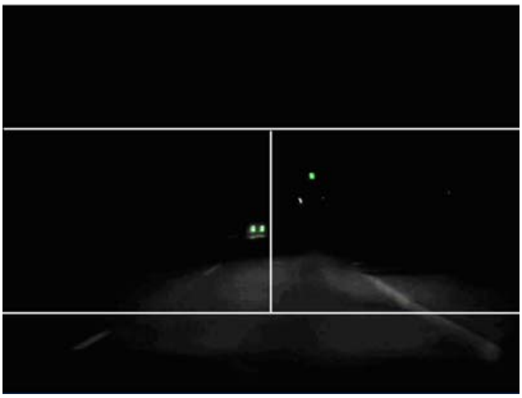

Fig. 1 The analyzed frame slice

This slice is divided into left and right sides – for more detailed position detecting rear lights. This way we have information about position of the overtaking vehicle. The outputs of this analyzes are information about:

- total number of rear lights (= number of red lights),
- number of rear lights on left side of my car,
- total number of front lights - incoming vehicles (= number of white lights).

The program is developed in Simulink and its “Video and Image Processing Blockset”, but the computation core is written as embedded functions in Matlab. For the developing and testing purposes, the program is equipped with graphical window showing real camera frame. The detected front and rear lights are marked in this frame with green – for front lights and red marks for rear lights.

The input raw RGB signal is preprocessed –

- removing upper and lower frame parts,
- filtering of the gray background – it is the typical color of the asphalt illuminated with front lights,
- converting rgb image to grayscale,
- Sobel’s edge detector – labeling possible positions of the rear and front lights,
- more detailed analysis this position in RGB image (frame) – selection of the red or white lights (the sub-function has parameters for setting “red” and “white” intervals),
- next step is the time filtering of the detected lights,
- as follows the sums of front lights (white) of incoming vehicles and rear lights (red) of overtaking vehicle are done (with the respect to their left and right positions),
- color marking of the detected lights in the frame – only for development purposes.

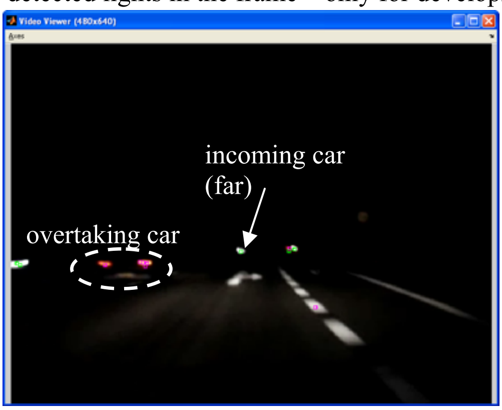

Fig. 2 The detected rear and front lights

2.1 Comment

The program was developed and tested off-line with video files due to high computing loading. The algorithm is going to optimize – rewriting "m" embedded function into faster form. Other possible optimization is decreasing the resolution of the processing image (now it is 640x480 pixels).

The used algorithm gives quite reliable results in case of detecting rear lights of overtaking vehicle(s) and rear lights vehicle in front of me.

The more complicated situation is in case of detecting front lights of incoming vehicle(s). During tests the street lights were detected as white lights of (incoming) vehicles. Likewise the spot-lighted traffic signs were evaluated as white lights. Only extraordinarily the rear and front lights were changed. The reason of it can be low sensitivity of the used color camera and its shaking. In the next tests we would like to use stabilized and more sensitive camera.

3 TUNNEL

The detecting of the tunnel entrance uses the same raw captured images from the camera as in case of detecting the dry/wet road surface. By help of this information can be lights switched on automatically. This system is supposed for daylight conditions. The image analyzing compares the parts of histograms of blue and green brightness channels - Fig. 3. In contrast to detecting of the dry/wet surface, this analysis requires a color camera.

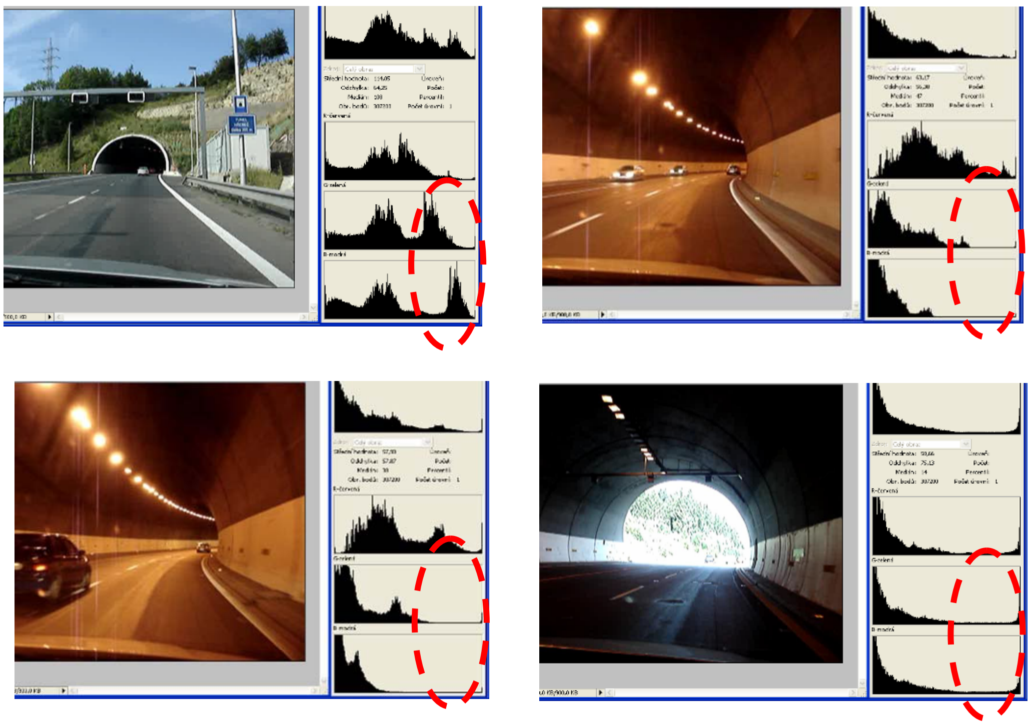

Fig. 3 The frames and their histograms in front and inside of tunnel

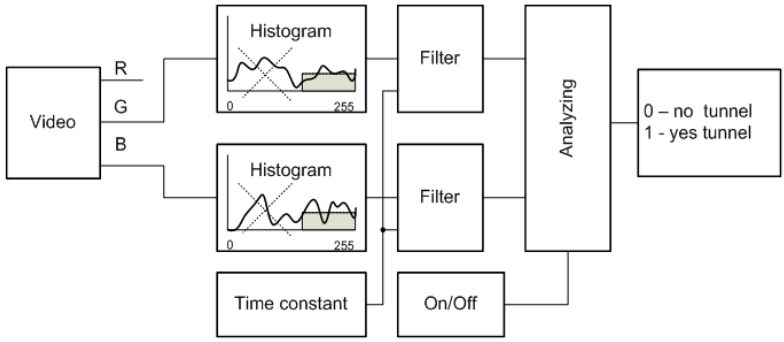

Fig. 4 Flowchart of tunnel detecting

From the flowchart is evident, that only upper histogram part is calculated. This simplifies and accelerates the execution. The algorithm is written in Matlab/Simulink software.

4 DRY AND WET

Presented detection of the wet/dry road surface is based on images acquired by camera(s) installed on rearview mirror of a car. The authors have tested two methods for recognition of dry/wet surface of the road. The first one is based on analyzing of polarization properties of images [1][3]. This method is suitable for daytime first of all. The second method is more focused on image analyzing of the RGB signal. In present, this algorithm is under final testing and provides quite stable results during daytime and nighttime.

As shown in Fig. 5, light reflected from a wet surface is polarized due to water in its indentations. The horizontal polarization component of light (*Rp*) reflected from a mirror surface is zero when the incident angle is equal to the *Brewster angle* – 53,1°. Vertical component increased with increasing incident angle. Irregular reflection occurs predominantly on a dry surface, so reflected light isn't polarized and reflection of polarization components is nearly equal (*Rs*=*Rp*). Since ratio of reflected polarization components isn't dependent on incident light intensity, analyzing of wet/dry surface is based on the comparison of properties pair of identical pictures – the first captured via filter with vertical polarization and the second with filter with horizontal polarization.

For testing purposes the camera subsystem was developed – see Fig. 6.

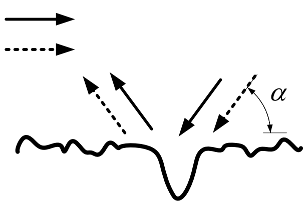

Fig. 5 Light reflection from road surface

Fig. 6 Camera subsystem with polarized filters

The algorithm is written in Matlab/Simulink software and is following:

- RGB video signal is converted to gray-level form,
- cutting the part of picture - rectangle front of car – see Fig. 7, (for left and right)
- comparison of these smaller pictures,
- histogram calculation and its analyzing,
- filtering of selected parts of histogram and deciding about kind of surface – wet/dry.

4.1 Comment

During tests there was a problem with the unequal focusing and sensitivity of both cameras and a little different scene on the left and right pictures. Likewise there was a problem with high demands on computing power of the used computer (notebook), which had online to capture two video signals, to do their preprocessing and analyzing. From mentioned problems the identical focusing and shooting are the most important for the practice.

Fig. 7 Analyzing part of picture – dotted rectangle

In the next experiments only one camera with the special polarized filter was used. The filter has the left section with the horizontal and the right one with the vertical polarization. The algorithm is similar to presented, except the slice. There is only one slice which is split to left and right parts. These parts are analyzed separately – the same way as mentioned above. The advantage of this method is its non-sensitivity to color nuances of road surface and cost reduction of the whole system. During tests the various ambient light conditions were tested – cloudy, sunny (including the various sun positions) and rainy. The series of the tests were accomplished on various kinds of surfaces – asphalt (fine, raw, various tones), concrete, and pavement blocks too. The evaluation of the both histograms (the left and right insets) was done with ART2 neural network. The histograms are divided into 8 bins and those are next with neural net evaluated. Hence, the input vector of the neural net has 8 elements.

5 HOUSE BUILDING

The presence of car in the inhabit area often requires to switch off the high bending during nighttime. This situation can be distinguished on base of the number of the actual operational conditions of the car. These conditions can be – typically: speed, domestic lightings, thermal radiation, road lighting and GPS. From possibilities mentioned above the domestic lightings was tested.

First the photo sensors as easiest solution were used. We tested the BPX81 and TPS851 (with integrated amplifier) phototransistors. The tests showed that using of those sensors is possible only on detection (measuring) of the overall ambient illumination. Next, as photo sensor the sensitive sensor NaPiCa was used and it was equipped with optical unit and instrumental amplifiers too. The output signal was analyzed in LabView software. But the realized results weren't too convenient.

The next group of tests used digital color camera, situated on right side car and aimed for its right surrounding under angle of 30° and 45° respectively. The image analysis is based on histogram evaluation. The both color and monochrome signals were tested. It was found that using the monochrome signal reaches good results - *Fig. 8*. And next the requirement on camera resolution isn't high and it allows using of cheap monochrome low resolution camera. The analyzing program was written under Matlab/Simulink software.

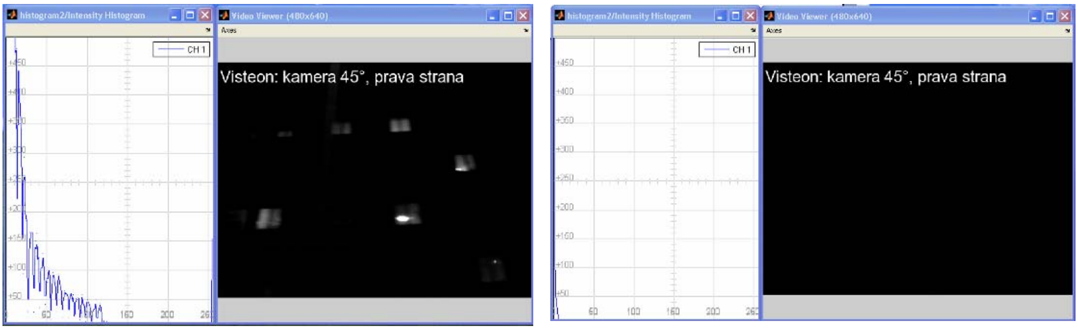

Fig. 8 The frames with detected shinning window (left) and without them (right).

6 CONCLUSIONS

The presented article describes the detection of the some properties of car surrounding like wet road surface, entrance to tunnel, rear and front lights of the other vehicles and presence car in the inhabit area. The sensory subsystem uses only information captured with color camera(s). For detecting of the house building there is used another cheap monochrome camera. Preprocessing and postprocessing algorithms are written in Matlab/Simulink software. Outputs of this subsystem are next processed by *Adaptive Front lightings Systems*.

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