Recognition System for Vertical Traffic Signs Using an Optical Correlator

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***Abstract*—The paper is focused on high-speed data processing by Cambridge correlator for recognition traffic signs in input scene. Optical correlator uses principle of optical fourier transformation. It could work with speed near speed of light. Research on this field has one's own place, because number of traffic signs is every day bigger and bigger. Drivers have to solve a lot of problems during driving a car. Development of assistant systems is dramatically mainly in automobile factories. This is essential reason, why one of many workgroup on Department of Electronics and Multimedia Communications at The Technical university of Kosice works in this field.**

Keywords— traffic signs, optical correlator, color model, recognition

I. INTRODUCTION

Every day is still more and more cars on roads in whole world, which has results in an reduced lucidity in traffic. A lot of signs along the roads are unreadable, damaged or covered by threes, billboards and many another things standing beside the road. The goal of article is to demonstrate of video assistant system for recognition vertical traffic signs, which can assist in orientation in the traffic.

Assistant systems are divided to the two main categories, active and passive. In the second chapter are described some basic properties in commercial assistant systems. Chapter three is devoted information about traffic signs. Color models are base for recognition program. This scope is described in chapter four. The proposal for hardware scheme is placed in chapter five. Next chapter is devoted practical implementation of program for recognition traffic signs. Chapter seven shows experimental results of system. The last chapter is devoted conclusions.

II. COMMERCIAL ASSISTANT SYSTEMS

Assistance systems for drivers are designed to help and protection passengers in an accident. It increases the safety of the crew of vehicle, driver comfort in the management of car and a lot of next things which have effect on road safety. Systems can be divided according to purpose:

- Passive,
- Active.

Passive assistance systems include parking assistant, who appears in the display instead of the car for easier parking and a variety of light and sound effects to alert the driver if it is close to obstacles. Those systems would be similar to the active, but the difference is in the fact that the passive systems call attention to the hazard or limiting the only. It hasn't effect to vehicle control.

Active assistant systems help to precede car accident, hazardous situation and thus maintain a preventive safety and free flow of traffic.

A. *Opel Eye*

Opel Eye uses a camera at the top of the windscreen to monitor the area in front of the vehicle. Information from the camera is continuously analysed to identify road markings and traffic signs. Road markings are used as the basis of the first of Opel Eye's two functions: lane departure warning.

At speeds above 60km/h, Opel Eye warns the driver if the car is about to veer inadvertently out of the lane in which it is travelling. The system can detect road markings and, if they are sufficiently distinct, unmarked road edges. The warning signal and a blinking icon on the instrument panel are suppressed if the system detects that the driver is intentionally leaving the lane: the driver's use of the direction indicators, steering, brakes and accelerator are used to determine whether the lane departure is deliberate or not [1].

B. *Lane Keeping Assistant System*

A camera mounted between the windshield and the rearview mirror determines if your vehicle begins to move away from the center of a detected lane. If you cross a detected lane line without using your turn signal, a message appears on the MID and a beep sounds. Steering torque is applied to keep your vehicle in the middle of the lane [2].

C. BMW Night Vision

The system consists of an infrared camera mounted in the front bumper which feeds a thermal image of the road ahead onto the screen in the middle of the dashboard. When it's dark outside, it picks up objects, humans and animals ahead of the car before they become visible to the driver in the headlights. Given that it has a range of 300 meters, BMW says it significantly enhances driving safety at night. The High-Beam Assist part is a complementary feature, which basically switches on the high-beam automatically when the car thinks it's sufficiently dark outside to warrant it [3].

D. Mercedes -Benz Night Vision

Mercedes vehicles have had night vision capabilities, and automatic object recognition, for years now. And while they can accurately recognize street signs, and other lifeless hazards, its only now that the company's fleet - starting with the 2014 Mercedes S-Class—will be able to recognize living, breathing obstacles like cows, moose, and deer. In fact in Europe, the S-Class actually shines a spotlight on the animal and tracks its movements so it's easy for the driver to spot at night, but unfortunately that feature has yet to be approved in the US [4].

III. Traffic signs

The role of traffic signs is to ensure a harmonious and safe flow of traffic on the roads. Most of the information is communicated to the driver by means of vertical and horizontal traffic signs. The number and density of traffic signs is increasing, and thus grow the demands on drivers while respecting the rules of the road. Especially in big cities are signs that regulate the speed limit, change-of-way, respectively determine the change of direction that the driver may be overlooked. For this situations motor car companies implement in cars safety equipments and systems for the recognition of traffic signs. These systems should help to respect all rules of the road traffic. As mentioned above, the signs are divided into two groups to:

- Horizontal signs on road (Fig. 1),
- Vertical traffic signs (Fig. 2).

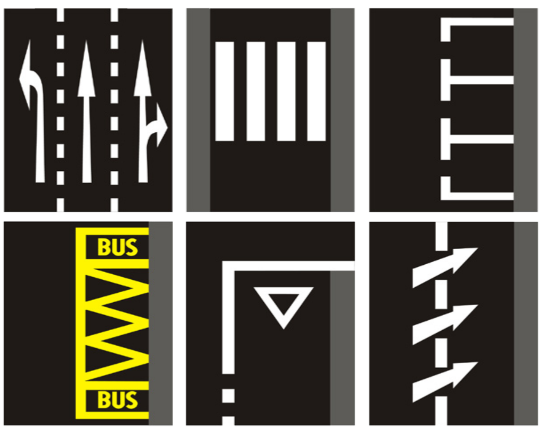

Fig. 1. Example of a horizontal traffic signs.

Fig. 2. Example of a vertical traffic signs.

IV. Color models

Working with colors in computer graphics requires precise selection and description of primary colors and how they are mixing (combine). Subjective ideas about how it is possible combine two colors are quite different. It‘s necessary to define relationships among the basic components of the color.

A set of primary colors and mixing rules for their color characteristics are defined in computer graphics using color models. High-quality graphics systems contain several models and permit the transfer between them.

A. RGB color model

The RGB color model is an additive color model in which red, green, and blue light are added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue. Fig. 3 shows model of RGB in the cube form.

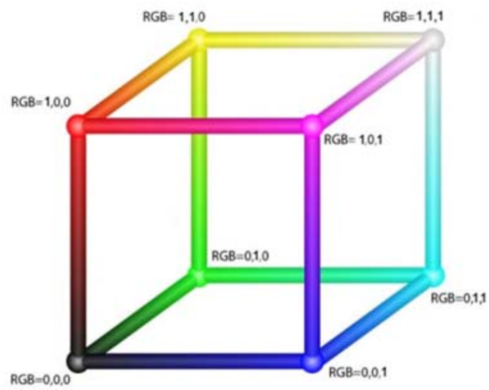

Fig. 3. RGB color model.

The RGB model is so important to graphic design because it is used in computer monitors. The screen you are reading this very article on is using additive colors to display images and text. Therefore, when designing websites (and other on-screen projects such as presentations), the RGB model is used because the final product is viewed on a computer display.

RGB model has its newer and improved specifications such as sRGB color model, which is a standard Microsoft Windows. Another enhancement of the original RGB model is AdobeRGB model created by Adobe [5].

B. HSL color model

HSL or Hue Saturation and Lightness (sometimes called “Luminosity”). While many web designers may be reluctant to use this model, you may discover that it is somewhat easier to use because it is a model based on how we perceive colors. Most people think of colors first by their hue, or the color it most closely resembles, such as red, green or yellow. If we want to reach the most "pure" color, we think about how close to red it is. This is the saturation. And finally we think about how close to white or black it is. This is the lightness. Model of HSL is showed in the Fig. 4 [6].

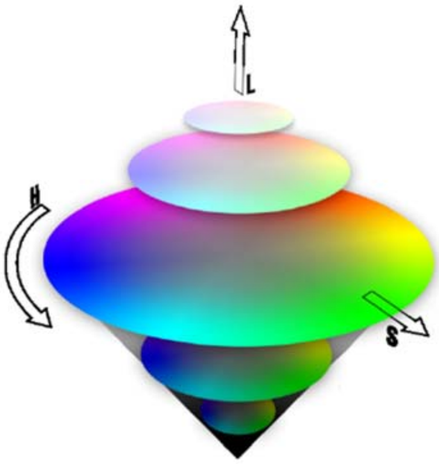

Fig. 4. HSL color model.

C. Color space CIE 1931

CIE stands for Comission Internationale de l'Eclairage (International Commission on Illumination). The commission was founded in 1913 as an autonomous international board to provide a forum for the exchange of ideas and information and to set standards for all things related to lighting. As a part of this mission, CIE has a technical committee, Vison and Colour, that has been a leading force in colorimetry since it first met to set its standards in Cambridge, England, in 1931.

The CIE system characterizes colors by a luminance parameter Y and two color coordinates x and y which specify the point on the chromaticity diagram (Fig. 5). This system offers more precision in color measurement than do the Munsell and Ostwald systems because the parameters are based on the spectral power distribution (SPD) of the light emitted from a colored object and are factored by sensitivity curves which have been measured for the human eye.

The colors which can be matched by combining a given set of three primary colors (such as the blue, green and red of a color television screen) are represented on the chromaticity diagram by a triangle joining the coordinates for the three colors (Fig. 5) [7].

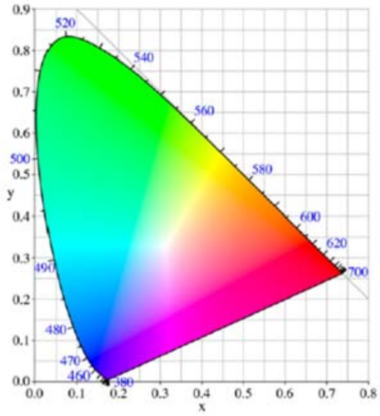

Fig. 5. Color space CIE 1931.

V. Block Diagram of Hardware Scheme

In the Fig. 6 is showed proposal of hardware scheme consisting of three bases parts (Scanning, Preprocessing / Evaluation, Optical correlation).

This system contains video camera for recording traffic situation in front of vehicle. Computer extracts region of interest (ROI). Next part of scheme is optical correlator which performing correlation between extract traffic sign and reference sign. Results of correlation are shown in the program. [8].

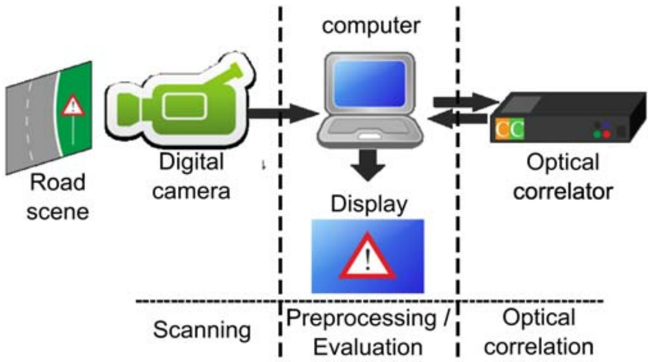

Fig. 6. Block diagram of hardware scheme.

Functional block scheme of system is showed in the Fig. 7 more definite describes operations of basic blocks.

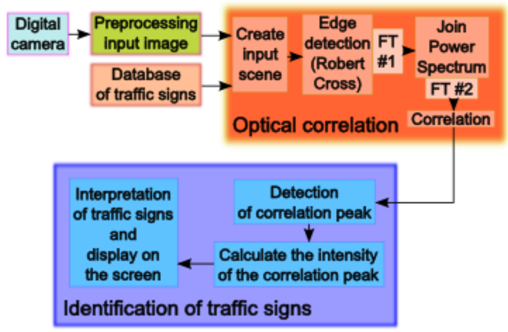

Fig. 7. More detailed description of block diagram.

VI. Implementation of the Proposed Program

As already mentioned, a system for traffic sign recognition using optical (Cambridge) correlator consists of three main parts, preprocessing, optical correlation and identification of traffic signs. Optical correlation is performed using the Cambridge correlator, which in addition contains the hardware and software FOE. Control program for correlator has been written in programming language C#. It was argument for choosing C# for following programming tools such as preprocessing and identification traffic sign.

For showing color filtration and ROI is needed to check item called Video processing. After marking check box Video processing is window extended to the bottom (Fig. 8). These windows are used mainly for experimental setting of filters.

In Fig. 9 we see how the window expands to the right side when the box Visible frame is checked.

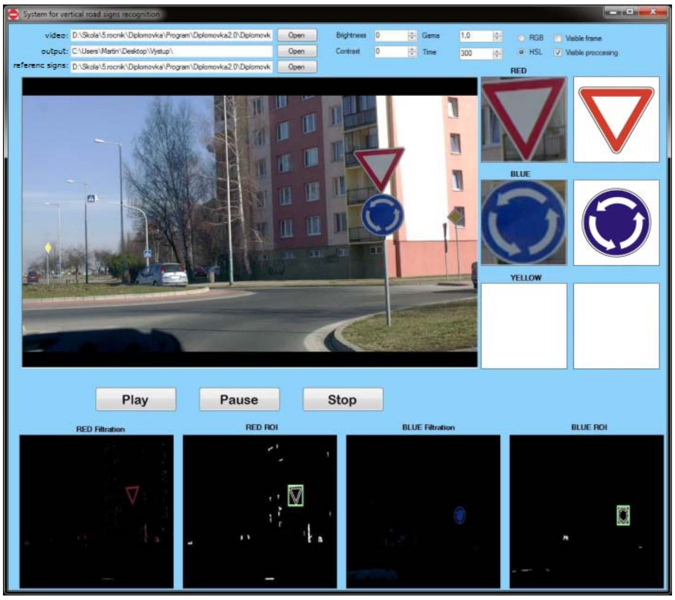

Fig. 8. At the bottom of the program is shown Video processing of input.

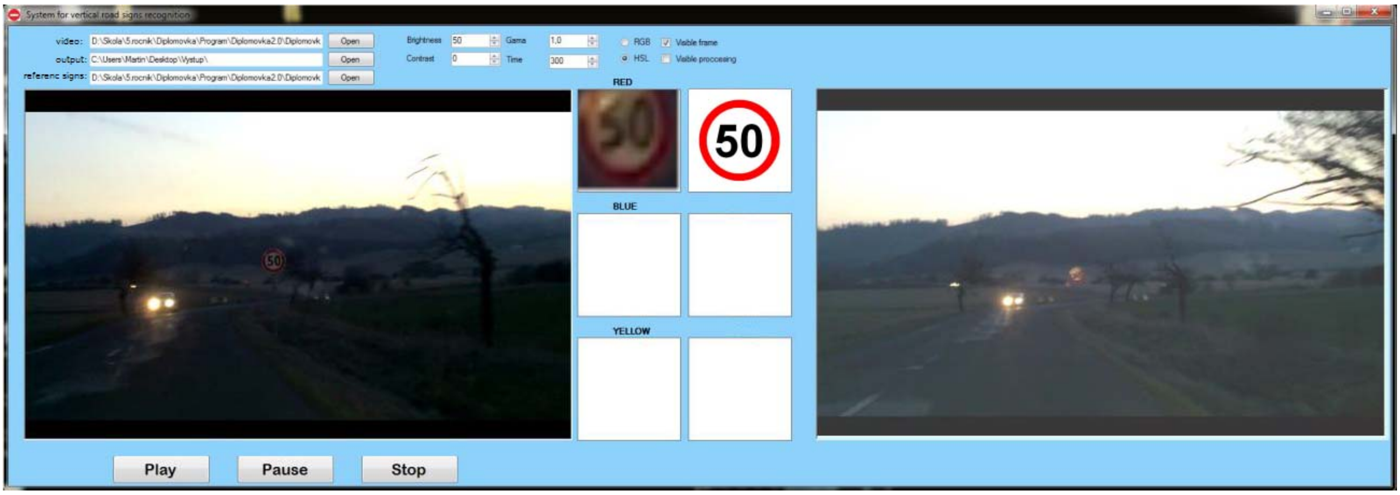

Fig. 9. At the right side of the program are shown Visible frames of input.

VII. Experiments

Experimental results were obtained from 471 road signs in real traffic conditions. The program uses color models RGB and HSL. The measured results are plotted in graphs Fig. 10, Fig. 11 and Fig. 12.

Fig. 10 compares the values obtained from both models in different conditions (rain, cloudy, night, twillight, sunshine). From Fig. 10 it can be seen, that Rain and Cloudy have higher values. This is due to saturation during cloudy weather is higher than in the sunshine. This increases the percentage of color recognized signs. Fig. 11 presents the results of detected and nondetected road signs in different light conditions. From the graph it is evident that both models achieve less than satisfactory results during the night when is low visibility. Fig. 12 shows the final results of the comparison models RGB and HSL.

In all experiments had HSL better results than RGB. The only exception occurred during the measurement at night, when is better achieved RGB values but the difference did not reach one percent.

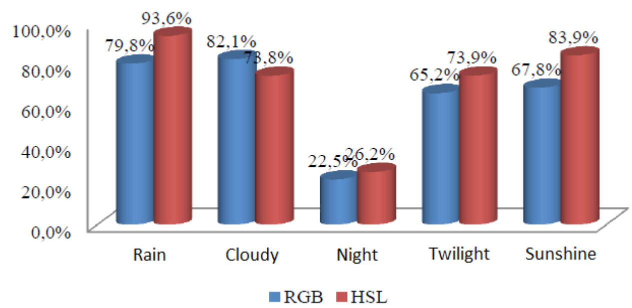

Fig. 10. Graph of comparison RGB and HSL in different conditions.

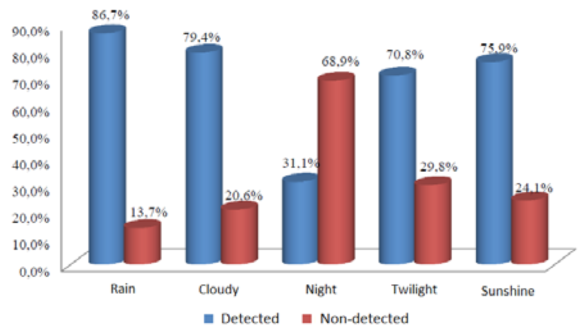

Fig. 11. Graph of detected and non-dected signs.

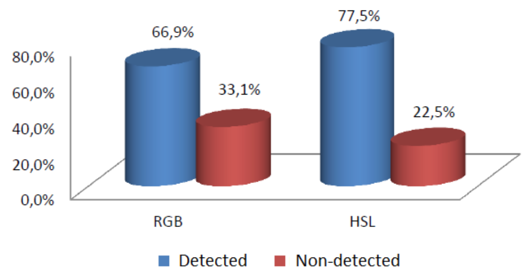

Fig. 12. Overall comparison RGB and HSL.

VIII. Conclusions

System was tested in different lighting conditions. From these experiments, we found that a great influence in this system has quality of input capture scenes. The higher quality of input scene entails, the greater correlation between the two traffic signs and it allows to scan signs from longer distance.

Article deals with the design and practical implementation. This system has field for improving in the future. The proposed system has demonstrated its advantages. The proposed system has suitable properties for practical use. With the increasing number of cars on the road and also an increasing number of road signs, the use of auxiliary systems for the driver is invaluable. During driving at high speed increases risk of neglect traffic signs. In this situations could help assistance systems.

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References

[1] Opel Insignia Owerview<http://opel-for-fans.blogspot.sk/p/opel-insignia-2008.html> [September 2014].

[2] LKAS<http://www.google.sk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fowners.acura.com%2Futility%2Fdownload%3Fpath%3D%2Fstatic%2Fpdfs%2F2015%2FMDX%2F2015_MDX_Lane_Keeping_Assist_System.pdf&ei=pjZAVPTfEsL5yQPP64LoBw&usg=AFQjCNEBk9eHyyxPKINulw67Y7K1mvgynw&sig2=PrEi0neU3JU8hoZZIt8XGA> [September 2014].

[3] L. Ju-Len “Bmw Night Vision : Smile! You're On Infrared Camera” < http://www.onemotoring.com.sg/publish/content/onemotoring/en/motoring_buzz/motoring_accessories/bmw_night_vision.print.html> [September 2014].

[4] Mercedes Vehicles Have Night Vision That Can Recognize Animals Now < http://gizmodo.com/mercedes-vehicles-have-night-vision-that-can-recognize-1226656905> [September 2014].

[5] J. GRIFFIN “What is a Color Model?”, < http://www.techexchange.com/thelibrary/ColorModel.html > [Januar 2013].

[6] R. G. Kuehni: "Color Space and Its Divisions: Color Order from Antiquity to the Present", Wiley-Interscience; 1 edition, ISBN 978-0471326700, 2003.

[7] J. Schanda Colorimetry: "Understanding the CIE system", John Wiley & Sons, Inc. Publication ISBN 978-0-470-04904-4, 2007.

[8] T. Harasthy, J. Turán, Ľ. Ovseník and K. Fazekas, “Optical correlator based Traffic Signs Recognition”, International Conference on System, Signal and Image Processing, Vienna, Austria, ISBN 978-3-200-02328-4, 2012.

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