Detector of Traffic Signs with using Hue-Saturation-Value color model

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***Abstract*— Paper describes design of color filter for preprocessing of input plane for Traffic Sign Recognition System. Driver Assistance Systems (DAS) are nowadays very popular topic of info-electronic. One of the most often cited topic of DAS is Traffic Sign Recognition System. This system is usually based on edge detection, neural networks or invariant transform e.g. Trace Transform. In this article is color filter designed for traffic sign recognition system based on optical correlator. Optical correlator compares two images or two-dimensional data sets in very high speed. Usage of optical correlator request specific preprocessing of input scene, which is described in this paper. Color filtering is one of basic steps of preprocessing of input data (video) for Traffic Sign Recognition with usage Optical Correlator.**

Keywords*— Color filtering, HSV color model, Optical Correlator, Traffic Sign Recognition.

I. Introduction

Driver assistance systems based on video processing are nowadays very popular topic. Increase of performance of vehicles makes cars more dangerous, so safety systems have to be improved as well. One way how to prevent accidents is make system which help to driver control traffic signs on the road [1-5].

There are several ways to recognition of objects (traffic signs) e.g. invariant transform, neural networks, or using optical correlator. Preprocessing of input image with specific request is individual for each of these methods. Optical correlator can compare images from captured scene with database of traffic signs. In this case is designed color filter which can remove all irrelevant colors [3,8,9,10]. Designed color filter is used as a main part of preprocessing input scene of recognition process.

Camera needs to be situated in car to capture traffic scene in front of car. Potential traffic sign (Region of Interest - RoI) is detected. After detecting ROI we can recognize this object, is it a Traffic Sign [2,6,7,9].

Method for detection of potential traffic sign (ROI) from static images and video is described in this paper. Traffic scene needs to be captured with digital camera from vehicle and processed with color filter to erase all irrelevant color pixels and than can be ROI defined [8,9,10,12].

HSV color model, which is used in color filter, is described in Chapter II. Chapter III is devoted to describe design of color filter. Chapter IV contains experiments with proposed color filter. Results of preprocessing are recorded. Conclusions are covered in Chapter V.

II. HSV Color Model

The color, which can be seen by human eye, can be defined as a light, resp. electromagnetic radiation that impact to retina and wavelength of visible light for peoples ranges from 380 nm to 740 nm. Color of some object can be defined as a wavelength of light, which is reflected by this object [11].

Color in digital space needs to be exact described, what is done by color models. We can define any color in digital space and describe their mixing with usage color models. Graphic systems contain several color models to describe color and description of convert between them. In this paper will be shown design of color filter based on HSV color model [11, 12].

HSV (Hue, Saturation, Value) color model, also called HSB (Hue, Saturation, Brightness) is one of the most popular color models to process color images in computer. This color model ideally represents perception of light by human eye. This model was invited in 1987 by Alvy Ray Smith [11]. HSV color model is commonly shown as cone as is showed in Fig.1.

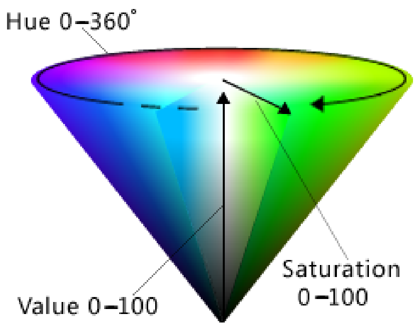

Fig. 1. HSV color model.

HSV color space consists of three components:

A. Hue

"H" as Hue describes the hue of color. For describe of color use colored circle (Fig.2) and any color is represented by angle, e.g. red color is around 0°, resp. 360°; green color around 120° and blue around 240° [9,11,12].

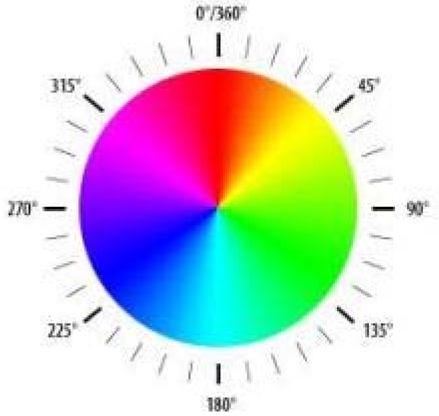

Fig. 2. Hue in HSV color model.

B. Saturation

Saturation of color describe intensity of color, resp. how white the color is. Mostly is defined in range from 0% to 100%, where 0% is absolutely unsaturated color and 100% represent fully saturated color.

Illustration of this component is showed in Fig.3 on blue color (any color could be chosen). In this image is unsaturated color shown as a white color because of the value (brightness) of chosen color is set to highest value. If value (brightness) was set to 50%, unsaturated color would be in grey and if brightness is set to 0%, unsaturated color would be black [11].

Fig. 3. Saturation in HSV color model.

C. Value (Brightness)

Value represents relative brightness of color. Same as saturation is mostly defined in range from 0% to 100%, where 0% is black color (no brightness) and 100% is white color (full brightness) [8,9,11]. Best quality of chosen color is around 50% of brightness. In this case blue color is chosen. Illustration of this component is showed in Fig.4.

Fig. 4. Value in HSV color model.

III. COLOR FILTER BASED ON HSV COLOR MODEL FOR TRAFFIC SIGN RECOGNITION SYSTEM

A. Design of color filter

Color filtering of input data is one of main parts of preprocessing input data for Traffic Sign Recognition System based on Optical Correlator. Color filter reduces color information in input data for faster processing in next steps. Optical correlator is used to compare reference and a captured traffic sign, so input scene needs to be reduced only for potential traffic sign (RoI detection). In steps after color filtering is filtered image processed for detect RoI in filtered image [12,13,14].

In this case, the color filter is optimized only for red and blue colors. Only red and blue traffic signs will be detected. With simple modification of parameters could be added more color. Filter gradually passes each pixel and if passed pixel is not within filter range (red resp. blue), color of pixel is set to black. Pixels which are within set range of filter keep their color. TABLE I. contains values of HSV parameters for red and blue color filter. The values were obtained experimentally and achieve the best results.

TABLE I. PARAMETERS OF HSV(B) COLOR FILTER

Filter HSL	Hue	Saturation	Value (Brightness)
RED	< 320˚; 5˚>	< 50% ; 100% >	< 30% ; 80% >
BLUE	< 200˚; 250˚>	< 50% ; 100% >	< 35% ; 90% >

Fig.5 show red color gamut of proposed color filter. Color gamut is illustrated in CIExy diagram and is bonded with black line. CIE diagram shows color spectrum which can be seen by human eye.

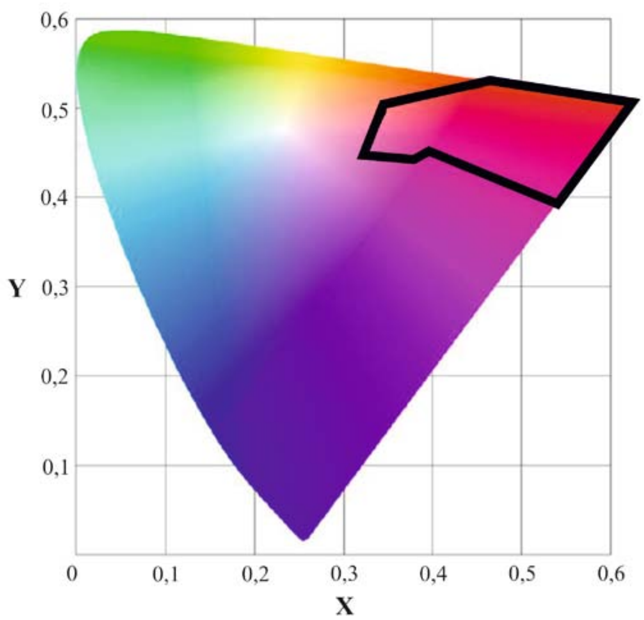

Fig. 5. Red gamut of color filter.

Fig.6 shows same CIExy diagram with bounded blue color gamut, which was chosen for blue color filter.

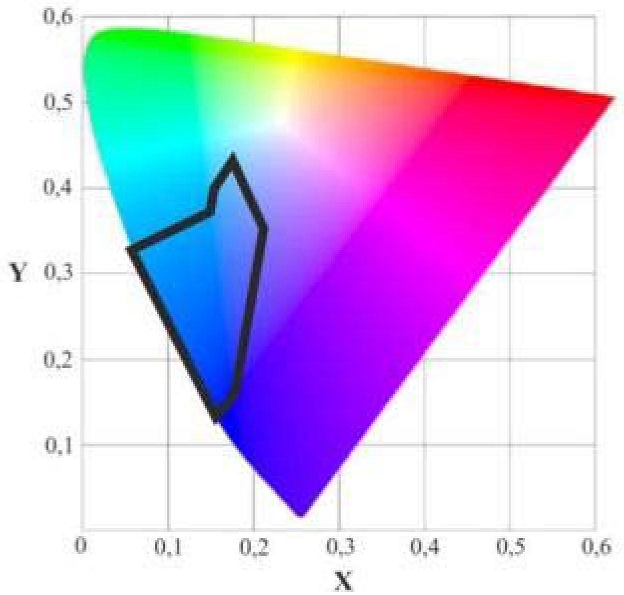

Fig. 6. Blue gamut of color filter.

B. Realization of color filter

Color filter based on HSV color model was designed in C#. If input image is coded in RGB color space, then is necessary convert input image to HSV color space. Right converted color image needs to be preprocessed before filtering begins. Preprocessing is done as follow:

Exposition correction is done on each input image. In HSV color space we do this correction by multiplication parameter “S” with constant 1,8 and parameter “V” by constant 1,35. The constants were chosen experimentally. Input image is after this correction a few over saturated, but the searching color is more recognizable.

Original and corrected input image is showed in Fig. 7.

Fig. 7. Correction of exposure.

In a next figure is showed result of color filtering. The red filter is used. Filtering is done by the rows, if the color of pixel is not in set range; color of pixel is set to black (Fig. 8).

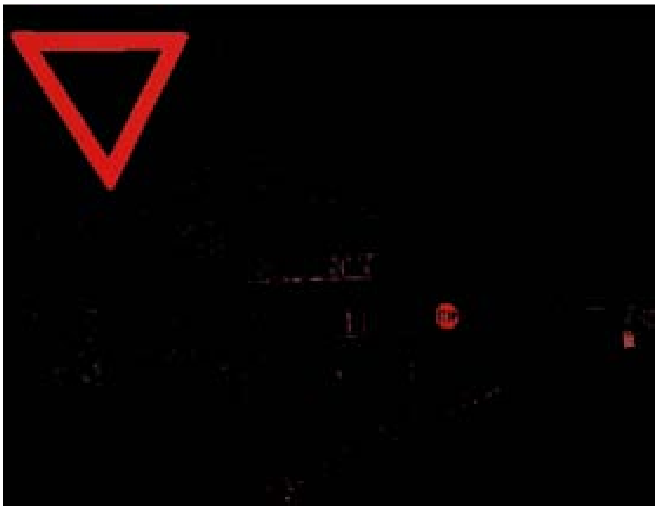

Fig. 8. Filtered input scene (red filter is used).

As we can see in the Fig. 8, color filter removed all irrelevant colors. In the figure are seen some irrelevant color clusters, which are not the part of traffic sign. In the next step, the irrelevant color clusters are deleted. “Too small” regions and “too large” regions are discarded. In first step, red point in image is found. Searching is done by rows.

After finding first red point, method called seed-fill is used. With this method we are finding regions. If region has size lower than 400 pixels (too small), then is discarded. If region has more than 16000 pixels (too large) then is also discarded. The regions which left are potential RoI for next processing. In Fig.9 is showed extracted traffic sign.

RoI is detected in preprocessed image after removing of irrelevant clusters. Regions which left are bounded around colored (not black) clusters. This border is shown in original input image (scene). Input scene is cropped around border and output of these processing is marked as Region of Interest. Cropped image contains around traffic sign background, which can make unwanted noise in correlation process.

In Fig. 9a is traffic sign after irrelevant clusters removing and in Fig.9b is showed RoI from origin input scene.

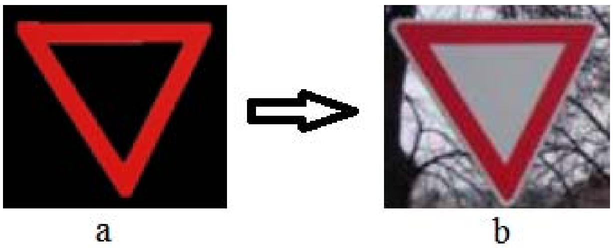

Fig. 9. RoI detection.

Next step of preprocessing is removing of background. Background removing is very simple step. Block of background removing assigns white color to each pixel until the pixel doesn’t belong to traffic sign (red color in this case). This simple step is repeated from each side (left, right, top a bottom). Result of background removing is showed in Fig. 10.

Fig. 10. Backgroung removing.

IV. EXPERIMENTS AND RESULTS

A. Experiments

Experiments with Detector of Traffic Signs (based on color filtering) were done with red and blue traffic signs captured on Slovak roads. Experiments have been done in ideal and bad light conditions (rain, night). In Fig. 11 is showed loaded input image with red traffic sign.

Traffic Sign is showed in process window. In this window are icons for explore the preprocessing process step by step. After load image we can see each step of preprocessing, exposure correction, and color filtering, irrelevant cluster removing, deleting background and detecting RoI.

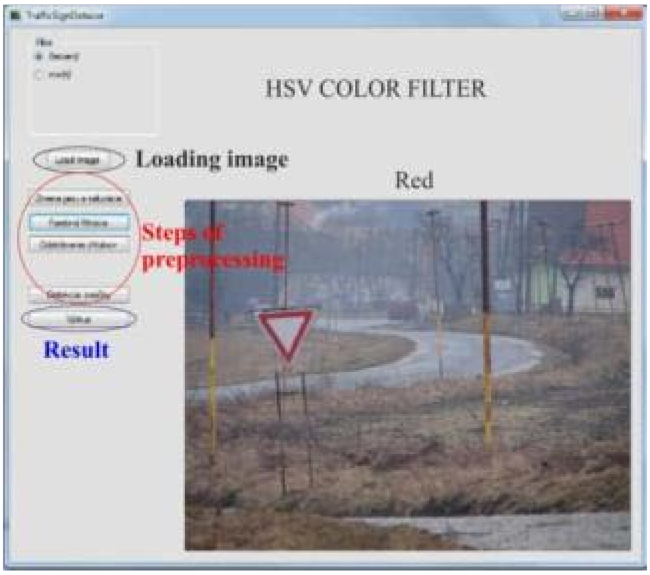

Fig. 11. Correction of exposure.

Initial window also include options for chose the color of color filter. In case showed in Fig. 11 is red filter chosen. Blue color of filter can be chosen with click to icon under the icon of red filter. Each step of preprocessing can be seen in picture box or we can skip all steps and see just the result.

These options are only if static image is loaded. If the video is loaded, only result (detected traffic sign) is showed.

B. Results

In experiments with red traffic signs were used STOP and “YIELD”. There were captured 36 input traffic scenes with traffic sign “STOP” and 25 traffic scenes with traffic sign “YIELD”. In Fig. 12 are showed 10 detected RoIs from traffic scenes, 5 from “YIELD”, and 5 from “STOP”.

Fig. 12. Detected RoIs, red color filter.

In next experiment were captured 35 traffic scenes with traffic sign “CROSSWALK” and 17 traffic scenes with traffic sign “Keep right” (Fig. 13). The same program for detection was used. After choosing blue filter were parameters set according to TABLE I.

All detected RoIs (traffic signs) were used in comparing process in optical correlator. Detected traffic signs were compared with original traffic sign.

Fig. 13. Detected RoIs, blue color filter.

Match between original traffic sign and detected RoI is represented as a pair of high localized intensities called correlation peaks. Intensity of correlation peaks gives information about correlation (similarity) between compared images.

Result of this paper is design of Detector of Traffic Sign based on HSV color model. There are many traffic sign detectors for traffic sign recognition system, with using many color filters. HSV color model give to us big advantage because of parameter “H”. Any color can be chosen with one parameter (H - Hue). Parameters S (Saturation) and V/B (Value/Brightness) are used only for exposure correction and make color filter more precise.

Detector for Traffic Signs is used as a part of Traffic Sign Recognition System based on Optical Correlator. Detected traffic sign is marked as a potential traffic sign and is compared with original traffic sign. Other systems are improved with shape detection due to better detection of traffic sign. Each improvement makes process time longer so, in this case the traffic sign detector uses only color filter. If any fail detection occurs, optical correlator ignores this RoI, what is faster than use shape detection on every RoI.

V. Conclusion

Detector of Traffic Signs described in this paper is based on HSV color model. In first chapter is used color model described. Parameter "H" in HSV color model allows choose color, which is needed for type of traffic signs. Parameters for Red and Blue color filter were recorded in Table 1. Color range was also illustrated in CIExy diagram. Experiments have been done on more than 100 traffic scenes. There were tested red and blue traffic signs. Examples of detections were illustrated.

Detector of Traffic Sign described above is designed for Traffic Sign Recognition System with usage Optical Correlator. Detected traffic signs are used as input images of correlation process. Corelation occurs between detected and original traffic signs. Result of optical correlation is pair of correlation peaks. Intensity of correlation peaks gives as information about similarity between detected and original traffic sign.

Intensity can be in range from 0% to 100%. Our experiments get similarity in range from 78% to 97%. Threshold of correct recognition was set on 75% of similarity, so success of detector was over 95%.

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