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DETECTION OF CZECH TRAFFIC SIGNS BY TEMPLATE MATCHING

CIP, P[avel]; HORAK, K[arel]* & CERVINKA, L[udek]

Abstract: *This paper deals with traffic signs detection in the urban environment in different weather and lighting conditions. There are color segmentation and method of shape recognition. Method has been prepared to detection all relevant traffic signs in three color combination valids in Czech Republic but in modified form, it can be applied to the territory of another country. A method has been successfully tested with the result above of 85%.*
Key words: *traffic signs, color segmentation, template matching, driver support systems*

1. INTRODUCTION

A traffic sign provides to drivers basics and advanced informations about traffic restrictions, determines them commands and prohibitions. Operates the transport system to avoid problems and traffic will be flowed. Autonomatic recognition of traffic signs is important for automated driving or driver assistance systems.

It supposed that vehicles will be autonomous and their behaviour more similar to real driver. On board systems warn the driver for inappropriate actions (e.g. speeding, taking a wrong way in an oneway street) or alert them for a change in advance. There are several ways to achive this detection. Most systems are based on knowledge of color composition and shape of traffic signs.

The main demands for the proposed system are speed, time cost and accuracy. Speed of algorithms must be sufficiently high that the system is able to work in real time. At the same time the system must be very precise; the driver must draw attention to all traffic signs and system can't detect fake signs (called as false alarms).

In outdoor environments, illumination changes, rotations, shadows and partial occlusion, make traffic signs difficult to recognize. Traffic sign recognition is divided into two stages: detection, which finds the regions of interest in an image containing traffic signs, and classification, in which detected signs are classified into road signs. We focused on detection.

This paper deals only with detection of traffic signs valid in the Czech Republic, but in modified form, it can be applied to the territory of another country.

2. TRAFFIC SIGNS DETECTION

2.1 Color segmentation

At the beginning of the work we were captured images from database of traffic signs according to valid regulations of the Ministry of Transport of the Czech Republic. Besides, they served as prototype for recognition of real world images. More images were taken from a real world in the city of Brno under various environmental conditions using a digital camera which was located in rearview mirror in the vehicle. In the Czech Republic, traffic signs only become red, blue or yellow and circle, triangle, rectangle or octangle shape.

The usual approach to the detection of traffic signs are segmentation by their colors. Color is a dominant visual featur, which undoubtedly represents a key piece of information used by drivers. Therefore color is widely used in traffic signs recognition systems, especially for segmentation of traffic sign images from rest of a scene. The color segmentation can be also used for finding the sign center. It is nesseccary to appreciate that this way can conclusion to different result by the weather and lighting condition. Another color has signs in the sunny days and another in the rain.

From testing sets of images (n=400) were manually selected about 5.000 points (pixels) from our images database. They were represented colors of main traffic signs. With their surrounding was created a sets of 140.000 points. From this set was able to create some detection algorithms.

The most intuitive color space is RGB system. The color of every pixel is defined by three components. Because of this, the color threshold has the following expression (Soetedjo & Kamada, 2005):

, (1)

where R(x, y), G(x, y) and B(x, y) are the values of the red, green and blue of point (x, y) in input image. TR is a red threshold. Red thresholding creates "blob" images useful for next process.

This way is very sensitive for lighting changes. That is the reason why other color spaces are used in computer vision applications; for example color detection in YCbCr color space known from face detect systems. Every pixel from sets were transform to a new YCbCr color space and created color search table to reduce time loss. But the results of detection by this model were not perfect. Another kind of color space is HSV defined by three components – hue, saturation and value. Color models define color relationships the same way the human eye does. The problem with HSV is the computional cost if special hadware is not used. We work only with value of Hue and Saturation. For example in red segmentation we must take a value of Hue in range 0-15 and 350-359 of degrees. Color detection in this space was able to use a precission separating value of Hue and Saturation or used Fuzzy systems with components as an input (Shojania, 2007).

Figure 1 shows a red and yellow detection on color images in various color spaces at RGB, YCbCr and HSV. With white color was highlighted a red areas and with gray the yellows. It can be seen (although it is in greyscale picture is not clear) that segmentation in the RGB has been detected erroneous detection of the yellow building as the red area.

(a) (b) (c) (d)

Fig. 1. Color segmentation at various color spaces: (a) input image; (b) RGB; (c) YCbCr; (d) HSV.

2.2 Shape classification

It is necessary to decide if the region has a shape of some traffic signs – triangle, octangle, rectangle or circle, because segmentation generates many false areas which were caused by rear light of the car, a red flyer advertising, yellow leaves on the trees and many other subjects. Therefore, in further progress each area is tested to meet the defined set of rules (size of area, aspect ratio of the width and height, etc.). Set of areas that meet the said rules, is called the set of detected symbols and is transmitted to the classification block.

Here it is possible to use several different approaches. One example is a method which uses edge detection (Canny, Sobel with threshold) followed by the DT - distance transformation (Gavrilla, 1999; Ruta, 2010). Then in the images is calculating correlation with a template of known shape (again with a calculated DT). In applications, a template is considered matched at locations, where the distance measure of correlation is under threshold. Another way for shape recognition is using of Corner detection (Shojania, 2003). He used sets of convolution cores for finding of corners. He supposed that if a left corner was found in the image, right corner must be on the right side at a maximum distance from that. Results from a combination of left and right corners then correspond to the detected shapes. Method can find rectangles, triangles and circles but not succeed to find traffic signs which are rotated or don't lies perpendiculat to the plane of scanning.

Next approach with the generic algorithm was used for circle sign detection (Soetedjo, 2005). A binary image was obtained by edge point extraction and edge points are separated into groups at left and right. By combining left and right fragments were founded parameters of ellipse.

However, the simplest method appears to compare areas with a template (Brogi, 2007). In the first phase of creating an algorithm was needed to create enough elements of training set. From the detected regions were selected and sorted out the appropriate forms of traffic signs, and shapes which were considered as a false detection. All these shapes were normalized to size 50x50 pixels. For example, the shape of a triangle numbered set of 30 elements, including the deliberately noisy and rotated data. For larger rotation of the lower edge (>10 °) was created another group. System is able to distinguish 14 different shapes (e.g. end of prohibiton, no stopping or standing or the stop sign).

Only areas with correct size and aspect ratio of the width and height could be comparing with template. Each of these is normalized to size 50x50 pixels and transformed to a row vector. Detection algorithm loads templates from database and transforms them into a row vector which is a part of matrix. Row vector of researched area is attached to each line of matrix and there is calculated a value of compliance with each row – correlation with line by the equation (2).

$$D(n) = \left| X - T(n) \right|^2 \qquad (2)$$

Where D(n) is difference between attached vector X and row of matrix T(n). In next step are selected ten lowest values (largest correspondence) of D column. If the value is less than a threshold and more than six values determined the same shape (same ID of the form) it is possible to consider that this area has the known shape.

2.3 Traffic signs recognition

If you already know the shape of area, there is no problem to cut out inner part and the pictogram use for classificator and decides the meaning of road sign. It can be used by calculating moments of invariants, by comparing pixel by pixel using neural networks or other decision principles. The work used the correlation with pattern which mentioned before.

The training sets were created by individual signs in sufficient quantities (delibaretely deformation, rotation and adding noise). However, it is important to realize the larger training sets, thereby increasing the computational complexity of the whole algorithm.

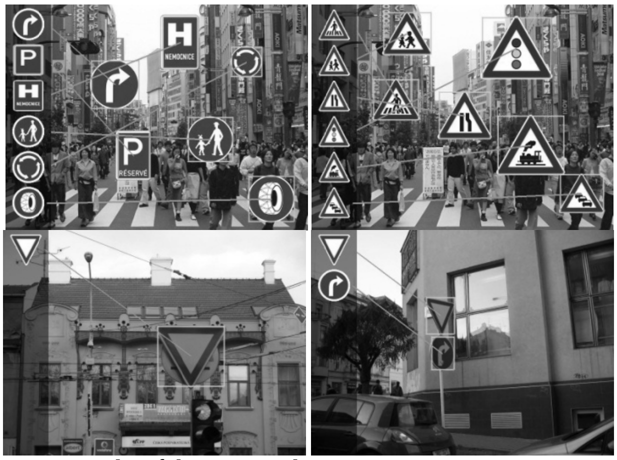

Fig. 2. Results of detection and recognition

3. EXPERIMENTS

We implemented our algorithms using MATLAB and tested it on a PC with 2.6 GHz. For test the execution time and robustness of our proposed method, we use artificial and real scene images. All are RGB images with resolution 800x600 pixels. Execution time for detecting every type of traffic signs on one image was about 720ms. If proposed method is written in another programming language (C++, C#), execution time will be better. System has detected 85% of potencional traffic signs and recognition about 80% of them. Figure 2 shows results of testing. First two images demonstrate the power of detection and recogniction on artificial images where are traffic signs placed on the street full of intrusive ads.

4. CONCLUSION

A method for the perception of traffic signs by template matching has been tested successfully. The algorithm has three main parts: color detection, shape classification and the classification of inner pictogram. All the algoritms can be achieved in real time with a PC and a pipeline image processing board. Above all, some improvements are the generating better sets of templates and pattern.

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