Neural Network System of Traffic Signs Recognition

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Abstract—This paper describes an approach for detection and recognition of traffic signs in real time with account for illumination and distance changes. A small single-board computer Raspberry Pi 2 and a webcam Hama AC-150 were used to implement the proposed algorithm. A scheme for determination traffic sign location uses color filter with morphological operators and Canny edge detector, identification of sign type is based on multilayer perceptron neural network. Variations of five traffic signs were used to train and test an algorithm. As a result experiments were successfully performed. Developed system is robust to light changes and is able to recognize traffic signs 20 cm in diameter from 1.5–2 m distance.

Keywords—Traffic sign recognition; pattern recognition; morphological operators; Canny edge detector; neural networks

I. Introduction

Traffic signs detection and recognition is an important aspect for providing safety for all the road users. Numerous computer vision systems have been developed recently for traffic signs analysis [1]. But the characteristics of existing algorithms [2–6] (recognition accuracy, false alarm percentage, robustness against atmospheric changes) are still not good enough to substitute a human operator.

This paper describes an approach for detection and recognition of traffic signs in real time with account for illumination and distance changes Variations of five traffic signs were used to train and test the algorithm: no entry for vehicular traffic, ahead only, turn right ahead, turn left ahead, ahead or turn right ahead. A single-board computer Raspberry Pi 2 and webcam Hama AC-150 were used to implement the developed approach.

II. Camera Image Processing

All the given traffic signs have common features: round shape and red or blue background color; therefore, the first stage is selecting red and blue areas of an image. Input video signal consists of a series of frames, each rendered in RGB space. Finding a red colour in such a space requires three components to be analysed, however changing the R parameter would inevitably influence G and B values. Therefore, it is expedient to opt for HSV space that allows selecting red colour more efficiently than RGB space [7]. It should be noted that HSV colour model is most congenial to human colour perception. Colour coordinates shall be within the following ranges after transformation: $0 \le V \le 255$, $0 \le S \le 255$, $0 \le H \le 360$.

Gaussian Filter (noise removal) and colour filters (locating sign outlines) were used for primary. Besides, morphological operators were used that represent the following operations applied to images: image erode and dilate. The results of applying morphological operations are shown in Fig. 1.

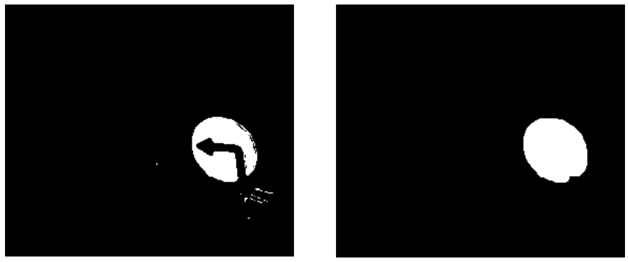

Fig. 1. Selecting sign's area (from left to right – before applying morphological operations, after applying morphological operations)

Red and blue areas detected, all closed loops possibly present on the image should be selected. Canny edge detector algorithm and contour search method was used to this end [8]. Too small contours and those with unsuitable shape should be discarded. The result of selecting most suitable contours is shown in Fig. 2.

Fig. 2. Selecting sign's contour

Thus, sign's location area shall be considered as correctly detected when a red or blue ellipsis is found with a specified aspect ratio within a selected range.

3. Traffic sign identification Sign's location area defined, it is necessary to define the meaning of the traffic sign and discard contour detector's false alarms.

Above all, the image of the sign should be adjusted to a common size. The contour is outlined with a rectangle and an area proportionate to the rectangle's dimensions is cut, then the area is scaled down to 20x20 pixels. The result of selecting a region of interest is shown in Fig. 3.

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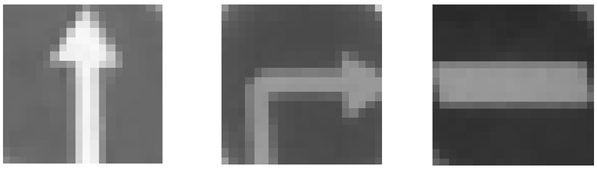

Fig. 3. Selecting a region of interest

Next, such an image is sent to neural network input with multilayer perceptron architecture. In order to reduce neural network learning time and to be able to implement the algorithm in real time it is necessary to reduce the number of components of the input vector. To this end, the obtained region of interest is transformed into an image of grey shades and the average brightness value of all the pixels is calculated. Next, 20 vertical and 20 horizontal parameters are calculated by comparing brightness value of every pixel with the average brightness value of the scaled region of interest. Besides, average values of colour tone, saturation and colour (HSV) within the region of interest are calculated. As a result of these transformations there are 43 components of input vector for a neural network.

The architecture used for operation of the neural network is shown in Fig. 4.

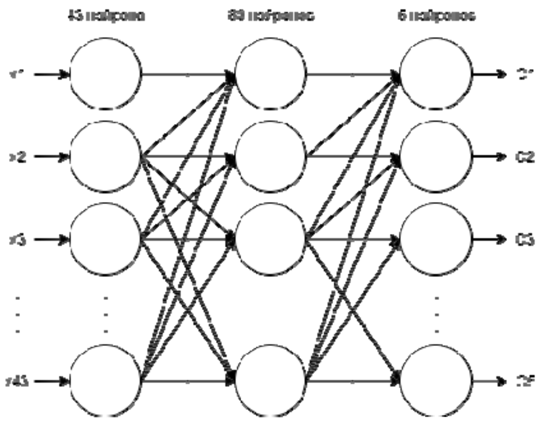

Fig. 4. Neural network architecture

Output layer of the neural network consists of 5 neurons, every of them assigned to a separate traffic sign. If the output amount exceeds 0.98, we consider the sign to be identified correctly.

In order to avoid false alarms, time filter is used; four consecutive frames are checked for the presence of one and the same sign in a specified image area; if this is true, it is possible to say with high accuracy that there is a specific traffic sign present on the image.

The results of the neural network operation are shown in Fig. 5.

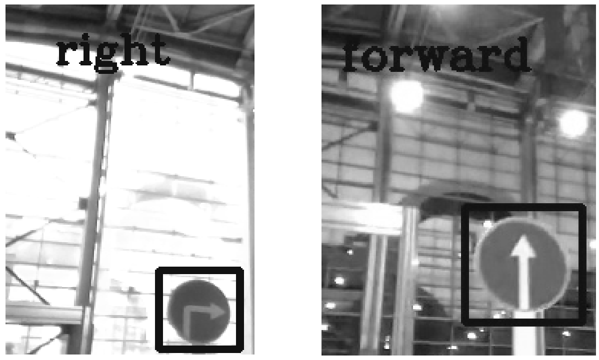

Fig. 5. Sign recognition

The algorithm provides image processing with a speed of 15 frames per second on Raspberry PI 2 hardware platform. During a test set the algorithm showed successful recognition in more than 87% of cases. The reached accuracy and processing speed of the designed algorithm are acceptable and allow using this approach in similar real time systems.

III. Conclusion

A traffic sign recognition algorithm was designed using a single-board computer Raspberry Pi 2 and a webcam Hama AC-150. Tests were run successfully on a prototype four-wheel vehicle. Test results showed that suggested solutions were correct. The developed system is robust to light changes and allows traffic sign recognition at a distance of 2–2.5 m (traffic sign diameter being 20 cm) what taking into account the scale of the mobile robot used (1:8 of actual size) is enough for a maneuver.

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