# Road Traffic Sign Saliency Map Model

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## Abstract

*In this paper, we propose a new pre-processing method for detecting road traffic sign based on visual saliency map model. Since the road traffic sign boards have dominent color contrast against environment, we consider the color opponents information with center surround difference normalization as an input feature extraction, which is effective to reduce noise influence as well as intensify the sign board color characteristics. Also, the edge feature map is considered to reflect the shape characteristics of the traffic sign boards. The weighted sum of the color feature map and edge feature map finally constructs road traffic sign saliency map. Computational experiment results show that the proposed method can successfully reinforce a road traffic sign board and inhibit the complex background traffic environment.*

**Keywords**: road traffic sign, color opponent feature, Gaussian pyramid, on-center off-surround difference normalization, road traffic sign saliency map

## 1 Introduction

Recently, automatic road traffic sign recognition system has been received more attention from the computer vision research community for implementing an advanced driver assistance system and an interactive workload manager which can support and disburden the driver to significantly increase driving safety and comfort [1, 2, 3].

The problem of traffic sign recognition has some beneficial characteristics such as unique design of traffic sign board, which means the sign shape variations are small, and significantly color contrast against the environment [2]. So, several color-based sign detection model and shape-based sign detection model introduced using these beneficial characteristics [4,5,6,7].

Event through these models have a good performance for detecting the road traffic sign, there remain number of challenges for successful recognition. First, weather and lighting condition are significantly varying in traffic environments, diminishing the advantage of the claimed object uniqueness. Additionally, as the camera is moving, additional image distortions, such as motion blur and abrupt contrast change, frequently occur. Moreover, the sign board installation and surface material can physically change over time, and are influenced by accidents and weather, which induces the rotation of sign board and degenerated color information [2].

Therefore, we propose a suitable pre-processing method to overcome those problems by intensifying a road traffic sign board besides by inhibiting complex visual environment with non-road traffic sign board areas.

Moreover, Some researcher have proposed saliency map model based on biologically motivated selective attention mechanism in human visual pathway to overcome those problem in general environment[9, 10, 11]. Thus, we also consider these models for making the road traffic sign saliency map.

Since the color information of a road traffic sign board mainly good contrast level against the visual environment, we consider the color opponents coding reflecting human visual characteristics [8, 9, 10] as an input signal which are red-green(r_g), blue-yellow(b_y), and red-green and blue-yellow(rg_by) color opponent. And, gaussian pyramid processing is adopted to make blur map and reduce noise influence in variable scene and size of road traffic sign for input feature images [9, 10, 11, 12]. We also adopt the on-center off-surround and normalization algorithm [9, 10, 11] to reinforce traffic sign area and inhibit non-traffic sign area.

This paper is organized as follows; Section 2 describes the proposed traffic feature map extracting model. The experimental results will be followed in Section 3. Section 4 presents our conclusions and discussions.

# 2 Road Traffic Sign Saliency Map Model

Figure 1 shows the proposed road traffic sign saliency map model. After zooming out a region in a visual scene, we can limit the processing area to reduce computation load. The red (R), green (G), blue (B) color features are extracted from the color input sensor. Then, the normalized red(r), green(g), blue(b), yellow(y) color features are extracted from the R, G, B [8,9,10]. The edge of red-green and blue-yellow color opponent(rg_by) features are considered as road traffic shape information in order to reflect load sign shape characteristic. Also, the r_g and b_y color opponent feature information are extracted from r, g, b, and y color features in order to reflect road traffic color characteristic. After we extract the edge and color information from the r, g, b, and y, the gaussian pyramid maps are considered for edge feature and color feature by r_g, and b_y color opponent features, which makes blur image to reduce noise. Using the center surround and difference normalization (CSDN) algorithm [9], the edge and color feature maps are built. Considering the weighted sum of edge and color feature maps, we can construct the road traffic sign board saliency map.

## 2.1 Color feature extraction

After zooming out and limiting the processing area for an input image, the R, G, and B color information

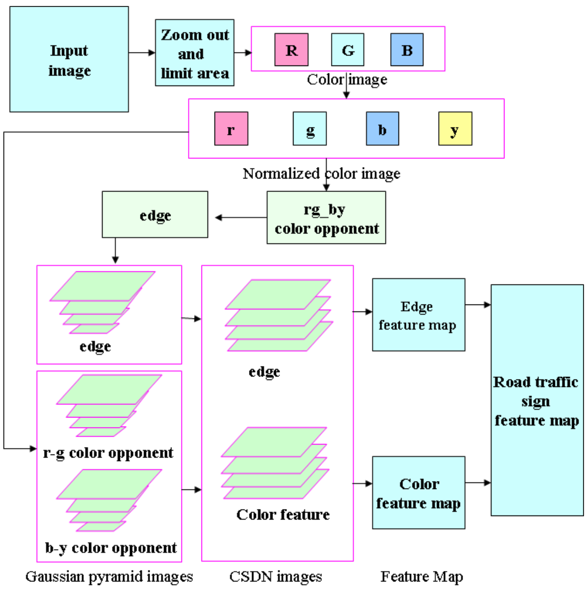


**Figure 1:** Proposed road traffic sign board saliency map model.

are extracted from input color image. And the normalized r, g, b, and y color features are extracted by equation (1).

$$
\begin{aligned}
r &= \begin{cases} R - \dfrac{G+B}{2}, & r > 0 \\ 0 & , r \le 0 \end{cases} \\
g &= \begin{cases} G - \dfrac{R+B}{2}, & g > 0 \\ 0 & , g \le 0 \end{cases} \\
b &= \begin{cases} B - \dfrac{R+G}{2}, & b > 0 \\ 0 & , b \le 0 \end{cases} \\
y &= \begin{cases} \dfrac{R+G}{2} - B - \dfrac{|R-G|}{2}, & y > 0 \\ 0 & , y \le 0 \end{cases}
\end{aligned} \tag{1}
$$

After extracting the normalized r, g, b, y color features, the rg_by color opponent feature is obtained by equation (2).

$$rg\_by(x,y) = \big\| r(x,y) - g(x,y) \big| - \big| b(x,y) - y(x,y) \big\| \tag{2}$$

The edge feature of rg_by color opponent is extracted by sobel operator as shown in equation (3).

$$
\begin{aligned}
e &= \sqrt{(rg\_by \cdot G_x)^2 + (rg\_by \cdot G_y)^2} \\
G_x &= \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \quad G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}
\end{aligned} \tag{3}
$$

where $G_x$ and $G_y$ are sobel operator[13].

Figure 2 shows experimental results for color and edge features.


**Figure 2:** the experimental result of extracted input color and edge features for proposed road traffic sign feature map extraction model.

## 2.2 Edge feature extraction

In general, the multi-resolution gaussian features shown in equation (4) are good for reducing noise and scale-invariant characteristic[12, 14].

$$E_\sigma = G_\sigma \bullet e \tag{4}$$

where $G_\sigma$ is gaussian function.

Otherwise, this method not only depends on the variance of gaussian function but also need many computation loads. So we adopt gaussian pyramid processing for constructing the multi-resolution feature maps as shown in Figure 3 [12]. In addition, we make 3x3 gaussian filter mask for reducing computation load.

After obtaining the 7 levels of gaussian edge pyramid features, we select 5 levels of gaussian pyramid features from $3^{rd}$ level to $7^{th}$ level. And then, selected 5 levels of gaussian pyramid are reconstructed in the same size of input image through zooming-In and gaussian filtering as shown in Figure 3. The CSDN algorithms perform to make edge feature map using equation (5) and equation (6) [9,10].

$$E(c,s) = |E(c) - E(s)| \tag{5}$$

$$\overline{E} = \bigoplus_{c=2}^{3} \bigoplus_{s=c+2}^{3} N(E(c,s)) \tag{6}$$

where "$\oplus$" represents across-scale addition , c means center which is finer scale image, and s means surround.

Figure 4 shows detail procedure of experimental results for edge feature map. As shown in figure 4, the 7 levels of gaussian pyramid features are obtained by zooming-out and gaussian filtering. And then, we select 5 levels of gaussian pyramid features which are from $3^{rd}$ level to $7^{th}$ level. After that, the selected gaussian pyramid features are reconstructed in same size of input image by zoom-in and gaussian filtering for CDSN algorithm. And, these gaussian pyramid features are making 4 level CSDN images. Finally, the edge feature map consisted by 4 levels of CSDN

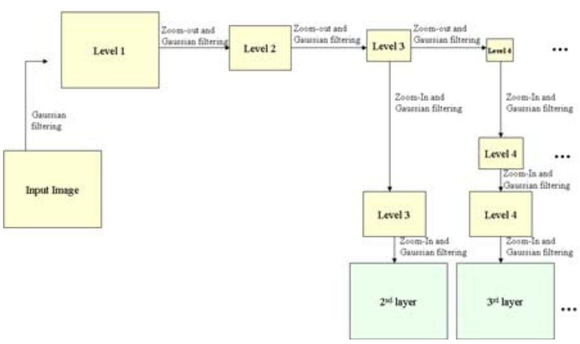


**Figure 3:** The procedure of constructing the gaussian pyramid features.

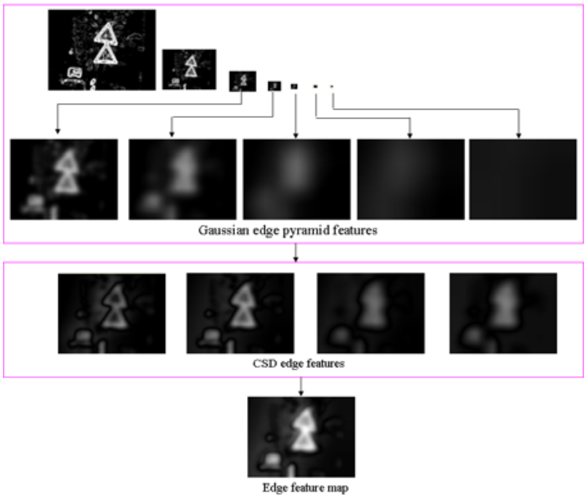


**Figure 4:** The experimental result of edge feature map.

images through cross summation and normalization. As shown in Figure 4, the edge feature of rg_by is very good feature for constructing road traffic sign saliency map.

## 2.3 Color feature map

After obtaining the 7 level the normalized r, g, b ,and y gaussian pyramid features using Gaussian pyramid feature extraction as shown in Figure 3, the 5 layer of reconstructed gaussian pyramid features are obtained the r_g and b_y color opponent pyramid features using equation (7). After that, the reconstructed 5 layer gaussian r_g and b_y color opponent pyramid features are making color feature maps of road traffic sign using equation (8) [9, 10] .

$$\begin{aligned} r\_g(c,s) &= |r(c) - g(s)| - |g(c) - r(s)| \\ b\_y(c,s) &= |b(c) - y(s)| - |y(c) - b(s)| \end{aligned} \tag{7}$$

$$\overline{C} = \bigoplus_{c=2}^{3} \bigoplus_{s=c+2}^{3} [N(r\_g(c,s)) + N(b\_y(c,s))] \tag{8}$$

where "-" represents the interpolation to the finer scale and point-by-point subtraction.

As shown in Figure 5, the 5 layers of r_g and b_y color opponent gaussian pyramid features are extracted from r, g, b, y. And then, these pyramid features are making 4 layer of CDS map. After that, the color feature map is consisted by 4 layers of CSDN map through cross summation and normalization.

## 2.4 Road traffic sign saliency map

After we get the color and edge feature map, the road traffic sign saliency map is extracted by equation (9).

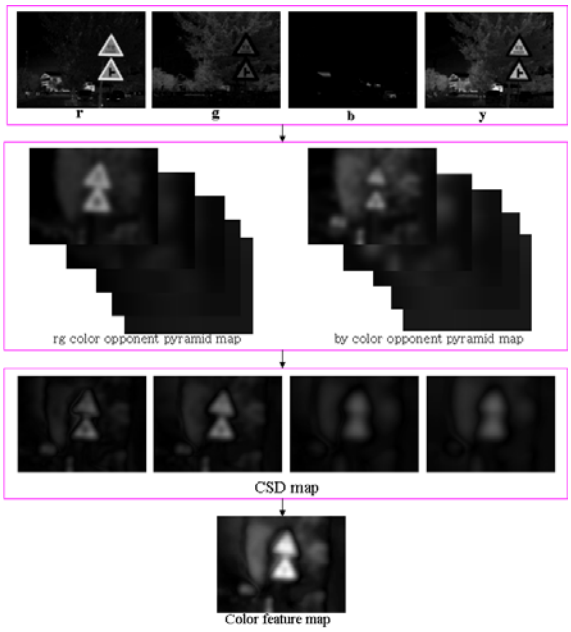


**Figure 5:** The experimental result of color feature map.

$$TS(x,y) = (W_c \cdot \overline{C}(x,y) + W_E \cdot \overline{E}(x,y)) \qquad (9)$$

where $W_c$ is the weight factor for color feature map and $W_E$ is the weight factor for edge feature map as respectively.

As shown Figure 6, our model can reinforce the road traffic sign areas and inhibit the non-road traffic sign areas.

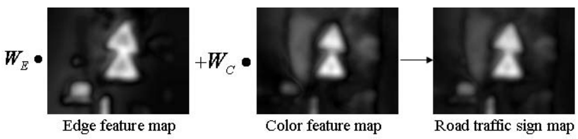


**Figure 6:** The result of road traffic sign map.

## 3 Experimental Results

In order to reduce the computation load of the proposed model, we consider the reduced size of an input image as 160 x120 rather than 320 * 240 and limit the processing area as respectively. Also, we make 3x3 gaussian filter mask as shown in equation (10) for making gausssian pyramid features. And, we set $W_c$ =0.5, and $W_E$ =0.5 for weight sum of edge and color feature map for making road traffic sign feature map.

$$G(i,j) = \begin{vmatrix} 2 & 13 & 2 \\ 13 & 40 & 13 \\ 2 & 13 & 2 \end{vmatrix} \qquad (10)$$

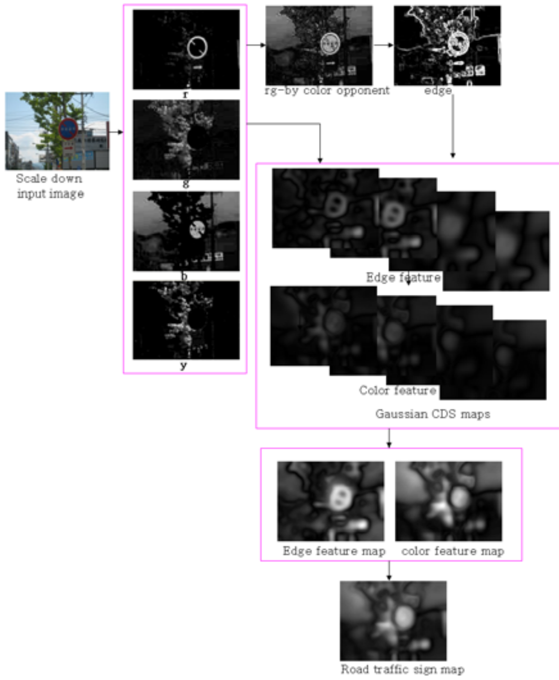


**Figure 7:** The result of road traffic sign map for every processing.

Figure 7 shows the experimental results for every process of the proposed model for extracting road traffic sign saliency map extraction. The proposed road traffic sign map extraction model effectively make more salient road traffic area then other areas as we consider the characteristic of the road traffic sign color contrast.

Figure 8 shows the result of proposed road traffic sign saliency map in various environment and road traffic sign. As shown Figure 8, our proposed model can robustly reinforce the road traffic sign area and inhibit the non-road traffic sign areas in complex visual environment with rotated road traffic sign and different size of the sign boards.

## 4 Conclusion

We proposed a new pre-processing method for detecting road traffic sign. In order to make more salient road traffic sign area than other areas, we consider traffic sign color contrast characteristic against environment. In the road scene, the proposed model not only successfully reinforces road traffic areas but also appropriately inhibit non-road traffic sign areas.

As further works, we are looking for more plausible process in order to select appropriate candidate road traffic sign areas. In addition, we are considering a method how to autonomously decide proper weight factors for each different feature in order to reflect relative importance of each feature for being able to characterize every specific sign in varying environment.

**Figure 8:** The result of road traffic sign map extraction model.

# 5 Acknowledgements

This work was supported by the Deagu Gyeongbuk institute of science and technology (DGIST) Basic Research Program of the MOST, and Components and Materials Technology Development Program, VISS(Vision-based Intelligent Steering System) Project. Specially, this research is commissioned by MANDO's sub-project IPAS(Intelligent Parking Assistant System).

# References


[1] J. G. Walker, N. Barnes and K. Anstey, "Sign Detection and Driving Competency for Older Drivers with Impaired Vision", *Proceedings the 2006 Australasian Conference on Robotics & Automation (ACRA2006)*, Auckland, New Zealand, December, 2006.

[2] L. Fletcher, G. Loy, N. Barnes, A. Zelinsky, "Correlating driver gaze with the road scene for driver assistance systems," *Robotics and Autonomous Systems*, vol. 52, pp. 71–84, 2005.

[3] C. Bahlmann, Y. Zhu, M. Pellkofer, et all, "A System for Traffic Sign Detection, Tracking, and Recognition Using Color, Shape, and Motion Information", *Proceedings IEEE Intelligence Vehicles Symposium 2005(IV2005)*, Las Vegas, NV, June 2005, pp. 255-260.

[4] H. Fleyeh and M. Dougherty, "Road and Traffic sign detection and recognition", *Proceedings the 10th EWGT Meeting and 16th Mini-EURO*, 2005.

[5] L. C. Gomez and O. Fuentes, "Color-Based Road Sign Detection and Tracking", *Proceedings Image Analysis and Recognition(ICIAR)*, Montreal, CA, Agust 2007.

[6] M. Benallal and J. Meunier, "Real-Time Color Segmentation of road signs", *Proceedings Canadian Conference on Electrical and Computer Engineering (IEEE CCECE 2003)* ,pp.1823-1826, 2003.

[7] G. Loy and N. M. Barnes, "Fast shape-based road sign detection for a driver assistance system", *Proceedings the IEEE/RSJ Intelligent Robots and systems*, pp.70-75, 2004.

[8] E.B. Goldstein, *Sensation and perception.*, 4nd ed. An international Thomson publishing company, USA, 1995.

[9] L, Itti, C. Koch, E. Niebur, "A model of saliency-based visual attention for rapid scene analysis," *IEEE Trans. Patt. Mach. Intell*, vol. 20, no. 11, pp. 1254–1259, 1998.

[10] S. J. Park, K. H An, and M. Lee, "Saliency map model with adaptive masking bsed on independent component analysis," *Neurocomputing*, vol.49, pp. 417–422, 2002.

[11] W. J. Won, S. W. Ban and M. Lee, "Autonomous Robot System for Environment Recognition", *Proceedings IAS-9*, pp.57-64, 2006.

[12] J.M. Ogden, E. H. Adelson, J. R. Bergen, and P. J. Burt, "Pyramid Methods in Image

Processing," *RCA Engineer*, vol. 30, no. 5, pp. 33–41, 1984.

[13] R. C. Gonzalez, R. E. Woods, *Digital Image Processing.* 2nd ed, Prentice-Hall, 2001.

[14] D. G. Lowe, "Distinctive image features from scale-invariant keypoints," *International Journal of Computer Vision*, vol. 60, pp. 91-110, 2004.