Image Processing Based Traffic Sign Detection and Recognition with Fuzzy Integral

Canan Taştimur[1], Mehmet Karaköse[2], Yavuz Çelik[3], Erhan Akın[4]
Departure of Computer Engineering, Firat University, Elazig, Turkey
canantastimur@gmail.com[1], mkarakose@firat.edu.tr[2], yacelik80@gmail.com[3], eakin@firat.edu.tr[4]

***Abstract*-Todays, the number of vehicles is rapidly increasing. In parallel, the number of ways and traffic signs have increased. As a result of increased traffic signs, the drivers are expected to learn all the traffic signs and to pay attention to them while driving. A system that can automatically recognize the traffic signs has been need to reduce traffic accidents and to drive more freely. Traffic sign recognition system meet this need. This study includes traffic sign detection and recognition application. In this study, some image processing techniques are used to detect traffic signs and Fuzzy Integral is used to recognize traffic signs. Both more accuracy rate results and low computational cost are obtained in terms of recognition stage by using positive aspects of algorithms taken as input parameters with Fuzzy Integral in the traffic sign recognition system. Experimental results show that proposed method gives high accurate results in a reasonable time.**

Keywords **– Traffic Sign Recognition; Color and Shape Segmentation; Image Processing; Fuzzy Integral**

I. INTRODUCTION

The vehicle driving has been more and more common in the life of people. Thus, the traffic security is very important. Traffic signs are used for traffic warning, regulation, routing and management as one of the important information for autonomous vehicle. These signs are intended to affect the behavior of drivers. Traffic sign is a computer vision technique of driving assistance system in automatically recognition roadside traffic signs. Traffic Sign Recognition (TSR) system plays an important role for automatous navigation system. TSR systems consist of two phases: detection and recognition.

TSR system extracts valuable information from the images taken by the camera mounted on the top of vehicles [2]. General block diagram of TSR system is shown in Fig. 1. In the first step it takes the images from camera. Region of interest (ROI) which may have traffic sign is extracted in second step. It makes use of the color and shape information for detection. This step should be strong and fast enough to diminish the total processing time of TSR of detected traffic.

In resent past a lot of research is carried out for the robust TSR system in literature. Many of them used the color and shape segmentation for traffic sign detection. C. Liu [1], made TSR system in three phases: a new ROI extraction, the split flow cascade tree detector, and a rapid occlusion robust traffic sign classification method based on the extended sparse representation classification (ESRC).

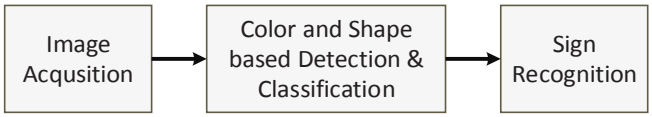


Figure 1. General block diagram of TSR system in literature [2]

J.N. Chourasia [2] detected traffic signs by using color centroid matching and recognized by using Perceptron Neural Network (NN). S. Yin [3], made a study of TSR systems for safety driving and used to Hough Transform in order to detect location of candidate regions. H. Fleyeh [4], proposed to a novel approach to detect traffic signs without color attributes. S. Kim [5] improved traffic sign detection process with HOG. K. Fu [6], recommended a novel machine learning based sign recognition system. Wahyono [7] made traffic sign recognition and tracking. M. Mathias [8] used to HOG features for detection and sparse representations for classification in TSR. Z. Huang [9], recommended a new method for traffic sign recognition by employing extreme learning machine (ELM). M. Boumediene [10] proposed sign candidates detection algorithm in order to reduce false positives in TSR. K. Fu [11] proposed a TSR method based on saliency enhanced feature and SVMs. C. Liu [12], designed a cascaded tree detector based on the MN-LBP features and a cascaded tree for TSR system. V. Andrey [13], recommended detection and recognition algorithm for restricting, warning and information road signs.

In this study, traffic sign detection and recognition have been made. The color and shape make traffic signs different from natural and human-made objects [2]. Colors of the traffic signs may be red, green, blue, yellow, black and white. While shapes of the traffic signs may be rectangle, circle, octagon and triangle. Warning signs include triangle shape with red colored border and white color background. Prohibitory signs include circle shape with red border and white background. Regulatory signs contain circle shape with blue background. Information signs include rectangle shape with blue background. Considering these features of the traffic signs, color and shape segmentation is performed in this study. Color and shape segmentation is primarily performed in order to detect traffic signs in the RGB format input image. Then Fuzzy Integral is applied to identify traffic signs with parameters which are outputs of TSR application in the literature. So, both low computational cost and higher accuracy rate results are obtained in terms of recognition stage with Fuzzy Integral in TSR.

978-1-4673-9555-7/16/$31.00 ©2016 IEEE

II. THE PROPOSED METHOD

Contactless image processing algorithm based on Fuzzy Integral is recommended in order to recognize traffic signs. The proposed method consists of 3 stages. These stages are Image Acquisition, Traffic Sign Detection and Traffic Sign Recognition. Block diagram of the proposed method is shown Fig. 2. RGB format image that is taken from camera is primarily given to traffic sign detection algorithm as an input parameter.

Traffic sign is detected with image processing techniques. Then the detected traffic sign is given to traffic sign recognition algorithm as a parameter and traffic sign classification is done by using Fuzzy Integral. This detected sign is an input parameter of the Traffic Sign Recognition System. Traffic sign recognition algorithm by using Fuzzy Integral both runs faster and gets more correct results thanks to associating positive aspects of algorithms in the literature. Flowchart of traffic sign detection algorithm of proposed method is shown in Fig. 3.

In the traffic sign detection stage, RGB format image is firstly converted to NTSC format image. Then, some filter techniques are applied to image. These filter techniques are respectively Unsharp filter, Avarage filter, Dilate filter and Erode Filter. The signs on the road image are made significant by applying these filter techniques. Finally, labeling of the sign regions is performed. In order to perform this, 'Area' and 'Ratio' parameters in Matlab are used. Mathematical expression of the ratio parameter is shown in Equation (1).

$$Ratio = MajorAxisLength \div MinorAxisLength. \quad (1)$$

The area and ratio parameters are used to separate from boundaries to parts and to extract features of the region [15].

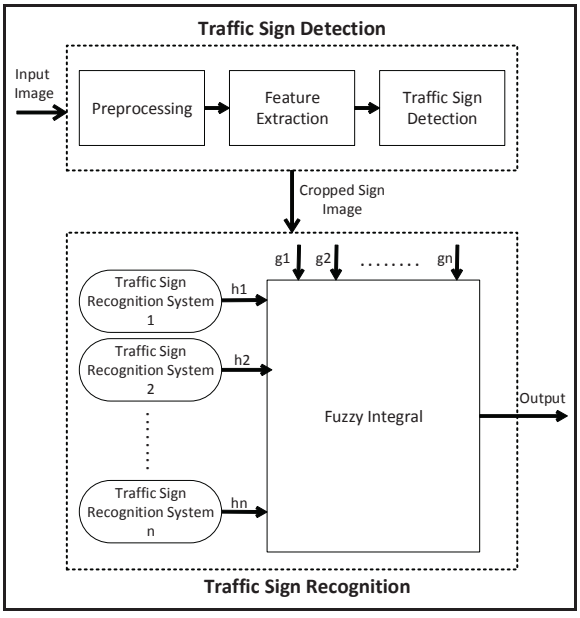


Figure 2. Block diagram of the proposed method

In Equation 1, *MinorAxisLength* returns a scalar value that specifies the length of the minor axis of the ellipse that has the same normalized second central moments as the region. Whereas *MajorAxisLength* returns a scalar that length of the major axis of the ellipse that has the same normalized second central moments as the region.

If 'Area' value of the identified region is greater than defined threshold value and 'Ratio' value is greater than determined value, this regional is labeled as traffic sign. Detected traffic sign images are given to traffic sign recognition systems as input parameters. This algorithm includes Fuzzy Integral method.

Fuzzy Integral is a type of nonlinear decision-making fusion methods based on fuzzy measure and fuzzy density [20]. *h1,h2,h3,.....,hn* values are results that are obtained from TSR algorithms and these results are input parameters of Fuzzy Integral. Results of selected TSR algorithms in literature have high accuracy rate and low time consumption. The other input parameters of the Fuzzy Integral are priority orders of TSR algorithms, which are represented as *g1,g2,g3,...,gn*. These priority orders refers to working order of the algorithms that are Traffic Sign Recognition systems.

Fuzzy Integral is a data gathering and joining in a multi-criteria environment through utilizing fuzzy measurement [14]. The Fuzzy Integral types are Choquet integral, Sugeno integral, Sipos integral, T-conorm integral, Lebesque integral, Aumann-Gould integral and Dunford integral [16]. The most simple and easiest of these ıntegral types is the Choquet integral.

In this study, Choquet integral type is used. Because the simplest of Fuzzy Integral techniques that is a classic integration of the advanced state, is the Choquet fuzzy integral technique given by Equation (2). The choquet fuzzy integral can be graphically shown in Fig. 4.

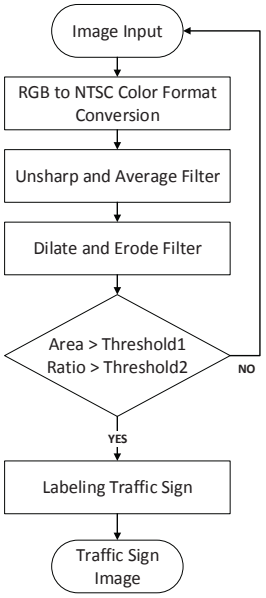


Figure 3. Flowchart of the traffic sign detection algorithm

978-1-4673-9555-7/16/$31.00 ©2016 IEEE

$$\int h(x) \times g = \sum_{i=1}^{n} [h(x_i) - h(x_{i-1})] \times g(A_i) \; ; \; h_0 = 0 \qquad (2)$$

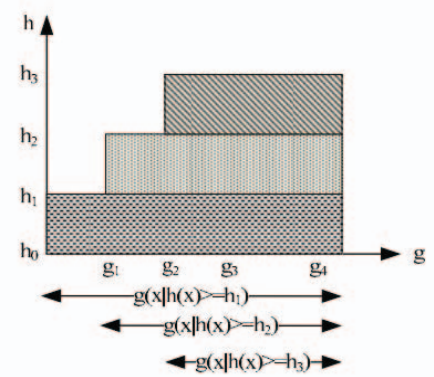


Figure 4. Choquet fuzzy integral [14]

In the Equation 2, the values of *h* function guarantee $h_n \geq h_{n-1} \geq \ldots \geq h_1 \geq h_0 = 0$ and each value of *h* should be positive definition. *h* function represents an evaluation of the confidence level of information according to each *x* value. Other function *g* can be taken as fuzzy weight factors [14].

As shown in Fig. 4, all h values are positive. All *h* values are ascending order [14]. It is known that the Choquet Fuzzy Integral is integral kind of positive definition [14].

III. EXPERIMENTAL RESULTS

A computer which has Intel (R) Core (TM) i7-2400 M CPU, 2.5 GHz, 6.00 GB RAM under Windows seven 64 bits is used to execute the proposed method. This proposed method is written in Matlab R2014b.

In this study, traffic sign detection and recognition are developed through using Fuzzy Integral. Feature Extraction is made in the proposed algorithm for traffic sign detection. Color conversion is firstly performed [17]. Then some filter techniques are utilized in order to reveal traffic sign [18]. Finally, detected traffic sign is extracted by cropping the image [19]. The proposed recognition algorithm both more produced accurate results and completed missing aspects of selected TSR algorithms in the literature.

In this study, we used to four TSR algorithms in the literature as input parameters of the Fuzzy Integral. First of these algorithms was accuracy rate 95% but recognized only speed limit traffic signs [5]. Second of these algorithms recognized the prohibitory and warning traffic signs [6]. But the information and regulatory traffic signs weren't recognized with this algorithm. Third of these algorithms didn't recognize the others except for the information signs [9]. The last of these algorithms recognized only triangle and circle shapes but other shapes weren't recognized [10]. A new output is obtained with aggregated of the mentioned TSR algorithms. In this way, the proposed algorithm is improved by be recognizing all the traffic sign types. Performance of the proposed traffic sign detection and recognition algorithms is shown in Table I.

Traffic sign recognition rates of TSR algorithms that are selected in literature and recognition rate of our method are shown in Table II. Sample values of input parameters of the Fuzzy Integral is shown in Table III. *h* values are accuracy rate of selected TSR algorithms. While *g* values are execution priority of selected TSR algorithms. Sum of the *g* values should be 1. Images which are given to proposed method as input and results of the proposed method are shown in Table IV. These results are traffic signs which the proposed method has detected and recognized to.

TABLE I. PERFORMANCE OF THE TRAFFİC SİGN DETECTİON AND RECOGNİTİON ALGORİTHMS

Algorithm	Elapsed time (Sec)	Accuracy rate (%)
Traffic sign detection	0.06	98
Traffic sign recognition	0.08	97

TABLE II. COMPARİSON RESULTS

Algorithms	Accuracy rate (%)
[5]	95
[6]	96
[9]	92
[10]	89
Our method	97

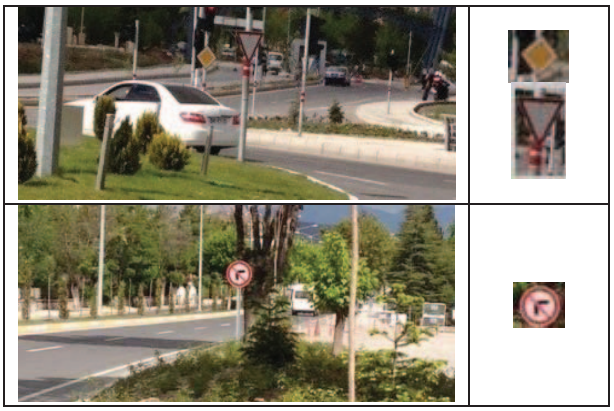
TABLE III. SAMPLE INPUT VALUES OF FUZZY INTEGRAL

Index	h values	g values
1	0.95	0.1
2	0.96	0.3
3	0.92	0.4
4	0.89	0.2

TABLE IV. EXPERİMENTAL RESULTS OF THE TRAFFİC SİGN RECOGNİTİON ALGORİTHM

Input Image	Recognized Sign
	
	
	

978-1-4673-9555-7/16/$31.00 ©2016 IEEE



IV. CONCLUSIONS

An algorithm based contactless image processing using Fuzzy Integral was suggested to detect and to recognize the traffic sign detection. Traffic sign was detected using traffic signs imaged under diverse angle and lightning cases and Regulatory, İnformation, Warning and Prohibitory signs were recognized with the proposed method. RGB to NTSC Color format conversion, Unsharp filter, Average filter, Dilate and Erode filter were applied to input images. So traffic signs were detected by applying these image processing techniques. Then some TSR algorithms in the literature were used to recognize traffic sign with Fuzzy Integral. All traffic sign types were recognized with Fuzzy Integral. The proposed method was run with utilizing traffic sign images in Matlab. Avarage recognition time of the proposed method was 0.14 seconds and accuracy rate of the proposed method was 98%.

REFERENCES

[1] C. Liu, F. Chang, Z. Chen and D. Liu, "Fast Traffic Sign Recognition via High-Contrast Region Extraction and Extended Sparse Representation", IEEE Transactions on Intelligent Transportation Systems, Vol. 17, January 2016.

[2] J. N. Chourasia and P. Bajaj, "Centroid Based Detection Algorithm for Hybrid Traffic Sign Recognition System", Emerging Trends in Engineering and Technology (ICETET), 2010 3rd International Conference on, pp. 96-100, Goa, November 2010.

[3] S. Yin and P. Ouyang, L. Liu and S. Wei, "A Fast and Robust Traffic Sign Recognition Method Using Ring of RIBP Histograms based Feature", Robotics and Biomimetics (ROBIO), 2014 IEEE International Conference on, pp. 2570-2575, Bali, Indonesia, December 2014.

[4] H. Fleyeh, "Traffic sign recognition without color information", Colour and Visual Computing Symposium (CVCS), 2015, pp. 1-6, Gjovik, August 2015.

[5] S. Kim and S. Kwon, "Improvement of traffic sign recognition by accurate ROI refinement", 15th International Conference on Control, Automation and Systems (ICCAS 2015), pp. 926-928, Korea, October 2015.

[6] K. Fu, I.Y.H. Gu and A. Ödblom, "Traffic Sign Recognition using Salient Region Features: A Novel Learning-based Coarse-to-Fine Scheme", Intelligent Vehicles Symposium (IV), 2015 IEEE, pp. 443-448, Seoul, 2015.

[7] Wahyono, L. Kurnianggoro, and K.H. Jo, "Traffic Sign Recognition and Tracking for a Vision-based Autonomous Vehicle Using Optimally Selected Features", SICE Annual Conference 2015, pp. 1419-1422, Hangzhou, July 2015.

[8] M. Mathias, R. Timofte, R. Benenson and L.V. Gool, "Traffic Sign Recognition – How far are we from the solution?", Neural Networks (IJCNN), The 2013 International Joint Conference on, pp. 1-8, Dallas, August 2013.

[9] Z. Huang, Y. Yu and J. Gu, "A Novel Method for Traffic Sign Recognition based on Extreme Learning Machine", Intelligent Control and Automation (WCICA), 2014 11th World Congress on, pp. 1451-1456, China, 2014.

[10] M. Boumediene, J.P. Lauffenburger, J. Daniel and C. Cudel, "Coupled Detection, Association and Tracking for Traffic Sign Recognition", Intelligent Vehicles Symposium Proceedings, 2014 IEEE, pp. 1402-1407, Dearborn, 2014.

[11] K. Fu, I.Y.H. Gu and A. Ödblom, "Automatic Traffic Sign Recognition based on Saliency-Enhanced Features and SVMs from Incrementally Built Dataset", Connected Vehicles and Expo (ICCVE), 2014 International Conference on, pp. 947-952, Vienna, November 2014.

[12] C. Liu, F. Chang and Z. Chen, "High Performance Traffic Sign Recognition Based on Sparse Representation and SVM Classification", Natural Computation (ICNC), 2014 10th International Conference on, pp. 108-112, Xiamen, August 2014.

[13] V. Andrey and K.H. Jo, "Automatic Detection and Recognition of Traffic Signs using Geometric Structure Analysis", SICE-ICASE, 2006. International Joint Conference, pp. 1456-1451, Busan, October 2006.

[14] M. Karaköse, I. Aydin and E. Akin, "The Intelligent Fault Diagnosis Frameworks Based on Fuzzy Integral ", Power Electronics Electrical Drives Automation and Motion (SPEEDAM), 2010 International Symposium on. IEEE, pp. 1634-1639, 2010.

[15] E. Rakun and M. Andriani, "Combining Depth Image and Skeleton Data from Kinect for Recognizing Words in the Sign System for Indonesian Language", Advanced Computer Science and Information Systems (ICACSIS), pp. 387-392, 2013.

[16] A. Croitoru and N. Mastorakis, "Estimations, convergences and comparisons on fuzzy integrals of Sugeno, Choquet and Gould type ",2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), pp. 1205-1212, 2014.

[17] C. Tastimur, E. Akin, M. Karakose and I. Aydin, "Detection of Rail Faults Using Morphological Feature Extraction Based Image Processing ", Signal Processing and Communications Applications Conference (SIU), 2015 23th, pp. 1244-1247, 2015.

[18] G. Karaduman, M. Karakose and E. Akin, "Experimental Fuzzy Diagnosis Algorithm Based on Image Processing for Rail Profile Measurement", MECHATRONİKA, 2012 15th International Symposium, pp. 1-6, 2012.

[19] M. Karakose and K. Fırıldak, "A Shadow Detection Approach Based on Fuzzy Logic Using Images Obtained from PV Array", Modeling, Simulation, and Applied Optimization (ICMSAO), 2015 6th International Conference on, pp. 1-5, 2015.

[20] Q. Wang, C. Zheng, H. Yu and D. Deng, "Integration of Heterogeneous Classifiers Based on Choquet Fuzzy Integral ",2015 7th International Conference on Intelligent Human-Machine Systems and Cybernetics, pp. 543-547, 2015.

978-1-4673-9555-7/16/$31.00 ©2016 IEEE