Designing a New Intelligent Image Processing Algorithm for Traffic Sign Detection and Recognition Based on Fuzzy Logic

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ABSTRACT: A new algorithm for traffic sign detection and recognition based on image processing was presented in this paper. This algorithm has three stages that consist of preprocessing, detection and recognition. In preprocessing stage, input image quality enhancement and unrelated data elimination be done by applying image processing algorithms. In recognition stage an intelligent machine vision algorithm is used to extract concepts of traffic signs. Detection stage is designed for decrease the operation time and increase the recognition algorithm accuracy. In this stage, traffic sign candidates are elected more accurately and they are transmitted to recognition stage. Fuzzy logic and mathematics is used in all of image processing and machine vision stages that consist of low and high level processing. Fuzzy logic and mathematics give Inference and intelligent capabilities to smart system to make correct decision in actual conditions like human. All stages of this algorithm was implemented in MATLAB. Also for performance investigation of this algorithm experimental scenarios in actual situation are designed. The results show that designed algorithm has an appropriate performance in traffic sign detection and recognition up to 92.68 percent in actual situations. Compared with other methods with the same experimental conditions the accuracy of the proposed algorithm is satisfactory. This algorithm can be used to design driver assistance and control systems for intelligent vehicles.

1- Introduction

Advanced Driver Assistant Systems (ADAS) improve the driving quality of vehicles. Traffic signs have appropriate environmental information that can help ADAS. Thus, traffic sign detection and recognition is very important to forward path features anticipation and decision making based on it. In recent years, Image Processing and Machine Vision algorithms have been developed to detect and recognize traffic signs [1].

Different methods have been presented for object recognition and understanding the concept of objects in an image. For instance, in one method, a set of patterns have been collected from different object positions. An adaptation algorithm compares input image with all patterns to find the best match [2]. This method is called pattern matching. Another one is a training method that consists of a training set of objects. This set is used to train Machine Learning [3] or Neural Network algorithms [4]. Support Vector Machine (SVM) [5], Nearest Neighbors [6] and Decision Trees [7] are some examples of the methods used in machine learning algorithms for TSR. But the last method deals with the object features in an image. Features are some of the object's physical characteristics that distinguish it from the same objects [8].

In this paper, a novel intelligent algorithm for traffic sign detection and recognition is presented based on Fuzzy Image Processing and object features method.

2- Traffic Sign Detection and Recognition based on Fuzzy Logic

The proposed intelligent algorithm consists of preprocessing, detection and recognition sections. Fig. 1 shows the algorithm diagram. In this algorithm, first of all, the input image from the camera is converted to HSV space and then a fuzzy image is created. Fuzzy image creation stage represents the features of each pixel like color, brightness along with linguistic variables. An adaptive Denoising algorithm is designed to clear outspread unwanted pixels in the fuzzy image. The aim of preprocessing section is creating an appropriate and intended image from the original image [9]. In detection section, fuzzy image and edge image are combined and labeling operation extracts the connected components. Detection algorithm investigates labels and determines which label is the traffic sign. Fuzzy rules for detection inference engine defined by feature points are extracted from traffic signs patterns. The aim of the detection section is finding object's primary information in an image [9]. Labels detected as traffic signs are checked with recognition algorithm. They are processed based on fuzzy logic and feature points to extract traffic signs concepts from candidate regions.

3- Results and Discussion

The presented traffic sign detection and recognition is designed in MATLAB software. Also, in accordance with Fig. 2, desired systems were mounted on a vehicle for practical tests. Vehicle system is used to check the performance of algorithm in urban environment and real situations.

Algorithm performance was tested throughout two experiments. In the first experiment, the algorithm analyzed some static images of the urban environment. Videos captured from real urban environments were used in the second experiment to check algorithm performance in confronting with real situations. The results show that the presented algorithm made a correct recognition that overcame some challenges like low light, blurring, same background color, and blocking part of the sign (Fig. 3).

According to experiments, the presented algorithm has a
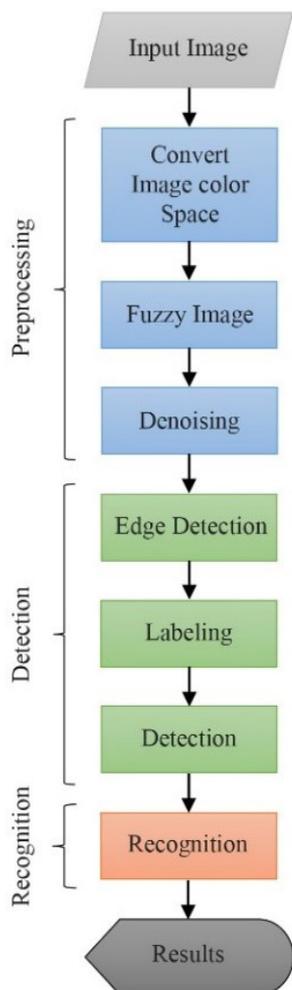
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Figure 1. Proposed Traffic Sign Detection and Recognition algorithm

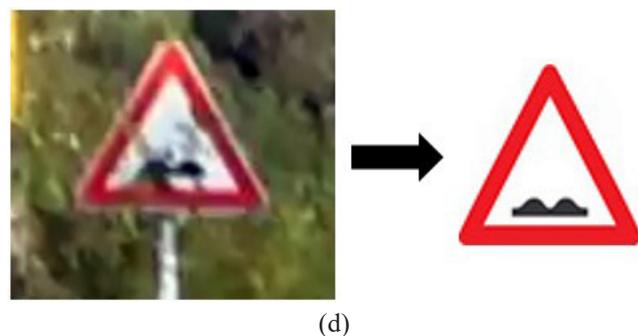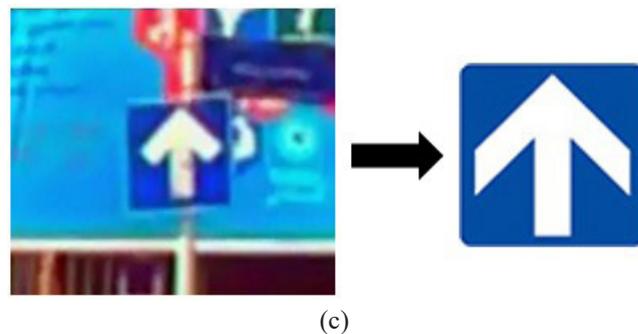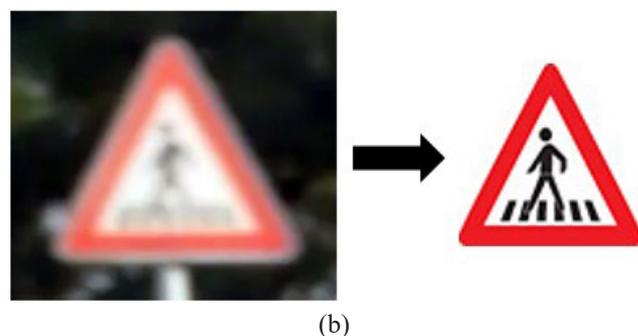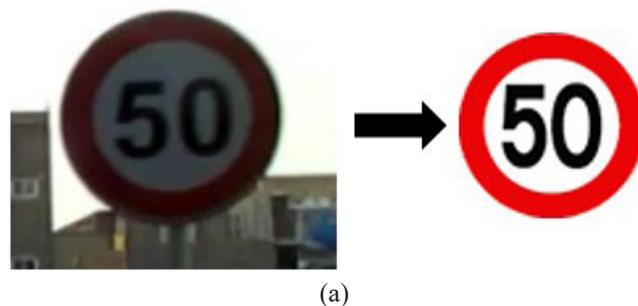**Figure 2. Practical vehicle**

Figure 3. Presented algorithm performance in some challenges. a- low light, b- blurring, c- same background color, and d- blocking part of sign.

satisfactory accuracy in different urban environments and different times of the day. Statistical results are presented in Table 1. Results of some other researchers who test their algorithms in the same situation are also presented in Table 1.

4- Conclusions

In this paper, an intelligent image processing algorithm was presented for traffic sign detection and recognition based on feature points and fuzzy logic. The algorithm detects traffic signs by color and geometric shape characteristics. Then, interesting feature points were investigated by designed

Table 1. Presented system performance compared with other research studies

Recognition Systems	Recognition Accuracy (%)
Gomez et al.: Ohta Method [10]	% 64.53
Gomez et al.: Normalize RGB Method [10]	% 65.66
Ruta et al. [11]	% 85.30
Bui et al. [12]	% 86.70
Lin et al. [13]	% 90.50
Presented Fuzzy Algorithm	% 92.68

fuzzy logic to extract traffic signs concepts.

The accuracy achieved in video experiment is 92.68 percent. Compared with the results of other research studies, this study proved that the presented algorithm is more suitable, more accurate, and more executable for practical and real-time traffic sign recognition systems.

Acknowledgment

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