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Road Traffic Sign Recognition Based on Genetic Algorithm

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Abstract: Traffic sign detection and recognition is an important part of the advanced driver assistance systems which can alert drivers about traffic rules and regulations hence increase driver safety. In this article, challenges and undesirable factors which affect performance of road traffic sign detection and recognition systems are discussed. The contributions of recent works and different methodologies are described in this paper. In the proposed method region of interest are extracted by using connected component and signs are successfully classified using Genetic Algorithm. The proposed method is invariant of colour and shape of signs.

Keywords: *TSDR, ROI, RFA.*

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I. INTRODUCTION

Successful driving is totally dependent on the visual information. Driver has to observe many things at a time continuously for successful driving which is not an easy task. Hence most of the accidents are occurring due to negligence of drivers, as they are not following the rules. Therefore, main purpose of making standard traffic rules and regulations is to guide road traffic and to increase road safety. For this reason, the traffic signs and signals are designed. By considering difference in languages the traffic signs are designed using symbols instead of words so that they can be easily recognized by human drivers. According to a recent survey one out of three people fails to recognize the most basic traffic signs. Only 56 percent of the drivers can recognize the traffic signs correctly. Hence it can be said that most of the traffic signs are not easily recognized by human drivers [1]. So, there is need of introducing such a recognition system which helps human drivers to easily recognize traffic signs and help them in their driving task.

Traffic sign detection and recognition is a part of the applied computer vision research. That performs the automatic detection and classification or recognition of traffic signs in scene images. Driving is a task fully based on visual information processing [2]. Traffic signs contain greater amount of information which is necessary for successful driving. They give information about current traffic situation, restrictions or availability of roads and risky factors. Traffic signs also help drivers in navigation by displaying no entry or turn left symbols etc. The traffic signs are placed in standard positions across the roads. Also, they are having specific colour and shape according to the international standards. Hence these features can be used for the detection. But there are some issues which make recognition of symbol difficult. Such as the traffic scene images may suffer from distortions due to noise similarly colour information is affected by varying illumination. Sometimes the traffic signs are covered by other vehicles partially. Many objects are present in traffic scenes which make the sign detection difficult. Additionally, the algorithms must be suitable for the real-time implementation i.e. it should have lesser computational time [3]. By considering above issues it can be conclude that to design a successful traffic sign recognition system, different types of image processing operations should be applied for the detection and classification of the traffic signs. So, they can help human drivers to understand traffic rules and regulation and to increase road safety.

II. RELATED WORK

The TSDR system can be divided into two stages, the detection and classification stages. In detection stage the traffic symbols are located in the input scene images. Whereas classification stage determines what type of sign the system is looking at. In other words, traffic sign detection generates candidate region of interests (ROIs). The traffic sign classification gets each candidate ROI and tries to identify the exact type of sign or rejects the identified ROI as a false detection.

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The traffic signs are having distinguishing features such as shape, colour and appearance. These features can be used for detection and recognition of them. Based on this detection methods are classified into three types like colour based, shape based and hybrid.

➢ *Colour Based Detection Methods*

Colour is a visual feature that can be easily noticeable. The colours used for traffic signs are according to the standard regulations and mostly they are primary colours such as red, blue, green. Colour based method [5-9] take advantage of this property and these colours are extracted to detect ROI within an input image.

The colour based detection methods have advantages like low computing and good robustness. However, colour based methods can be used with a high-resolution dataset but they are not suitable for greyscale image. The main problem with using the colour parameter is its sensitivity to various factors such as the distance of the target, weather conditions, time of the day, as well as reflection, age and condition of the signs.

There are different colour based methods such as colour thresholding, HIS/HSV transform, region growing, colour indexing, dynamic pixel aggregation, CIECAM97 model, YCbCr colour space.

S. Varun et al. [5] uses R, G and B values of each pixel. The sum of green and blue pixel components is then compared with 1.5 times the red pixel component for each pixel. Depending upon higher red component values segmentation is carried out. Experimental result shows the recognition rate of 82%. G. Tagunde et al. [6] firstly converted RGB colour space into HSV and then colour thresholding is used for detection.

S. Vitabile et al. [7] developed a system in which colour based segmentation is carried by region growing technique. Results show segmentation rate of 86.3% to 95.7% and classification rate of 88%. X. Gao et al. [8] presents a system in which test images are transformed from RGB space to CIE XYZ values and then to LCH (Lightness, Chroma, Hue) space using the model of CIECAM97. A. Hechri et al. [9] presents an approach in which the detection module segments the input image in the YCBCR colour space. In the YCBCR space, the colour value of a pixel is determined by the planes CB (blue chroma) and CR (red chroma). The Y component represents luma i.e. brightness.

➢ *Shape Based Detection Methods*

The traffic signs have specific colours as well as specific shapes. This particular feature can be used for detection of signs. The main advantages of shape-based detection method [10-12] are; they are invariant of light intensity and they reduce search area as shape detection concentrate on shape of the sign from a scene image. However, shape detection method has limitations such as they require greater memory and computations for large images. In addition, damaged, partially hidden, faded and blurred traffic signs may cause difficulties in detecting traffic signs accurately. The most commonly used shape-based approaches are Hough transform, Similarity detection, Distance transform matching, Edge detection features and Haar like features.

F. Zaklouta et al. [10] proposed traffic sign classification using different sized HOG (histogram of oriented gradient) descriptors and distance transforms. D. Deguchi et al. [11] proposed an intelligent traffic sign detector using adaptive learning. Edge detection is used for segmentation. The method obtains F-measure of 0.878 at maximum. V. Prisacariu et al. [12] proposed a real-time system that integrates single view detection with region-based 3D tracking of road signs. Detection is performed by cascading Ada-Boost classifiers that selects Haar-like features.

➢ *Hybrid Method*

Both colour-based and shape-based methods have some advantages and disadvantages. Therefore, to improve the efficiency of the TSDR system a combination of colour-based and shape-based features can be used. In the hybrid methods there may be two approaches like either colour-based detection take shape into account or shape detection is used as the main method but also uses colour features.

After finding region of interest in detection stage next step is to determine the content of the detected region of the traffic signs. This is done by classification stage. Some conventional methods used for classification [13-23] are Template matching, Decision tree, Neural Network, Deep learning method, Ada-Boost, Support Vector Machine, Genetic algorithm.

J. Greenhalgh et al. [13] used Random Forest Algorithm for the recognition of sign. A Random Forests classifier requires training with large datasets. But accuracy level is much greater. Results indicate the parameters as precision 83.3% recall 87.72% and F measure 0.85. In another paper. [14] they have used cascaded SVM classifier. To train this cascade SVM classifier HOG features are used. Hence improved parameters are precision 86.8% recall 80.7% and F measure 0.84. F. Zaklouta et al. [15] presents comparison of the performance of k-d trees, random forests, and support vector machines (SVMs) for traffic-sign classification using different sized HOG descriptors and distance transforms. Decision tree gives high accuracy and low computation time but the main limitation is that a large number of trees can make the algorithm slow and ineffective for real-time. The SVM classifier obtained the highest accuracy and lowest standard deviation amongst all other classifiers. The success rate is 92% to 96% but the main disadvantage is lack of transparency of results. J. P. Carrasco et al. [16] used two approaches of NN. Initially single stage neural network (SSNN) is implemented for each class of traffic sign and then cascade approach (CNN) is used. The drawback of NN is for the addition of one more road sign to the NN requires a new training of the net and manual selection of the training samples. J. Jin et al. [17] applied a hinge loss stochastic gradient descent (HLSGD) method to train convolutional neural networks (CNNs). C. Liu et al. [18] presents Ada-

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Boost based detection framework. The main advantage of the AdaBoost is its simplicity, high prediction power. Its main disadvantage is that the AdaBoost is initially trained classifier, it cannot adjust to new coming samples. They have to train again from the beginning, which is time consuming and require more memory to store all previous samples. In papers [19, 20] support vector machines is used as a classifier. Experimental result shows recognition rate up to 93.2%. But the signs having same colour for sign and the background are not detected and the required processing time is greater.

III. SYSTEM DESIGN

The identification of road traffic signs is usually carried out in two main phases, detection and recognition. Figure 1 shows the different processes included in road traffic sign detection and recognition system. In the detection phase some operations are carried out on input image such as pre-processing, feature extraction, and segmentation. The input image may contain distortions due to noise, motion, low resolution. To remove such type of distortion pre-processing is carried out. It is the first step in the detection phase. The pre- processing operation removes the distortions in an input image and gives corrected image. In the second step features are extracted from the original image. These features contain relevant information of the original image but in lesser amount. After feature extraction the process of segmentation is carried out. In which traffic symbol is separated from the background. It gives more information regarding symbol to be detected. In the last part of the detection phase the traffic signs are detected from the segmented images by using the extracted features of the previous part. In the entire process, efficiency and speed of the detection phase are important factors. Since it reduces the search area and gives features of symbol only. After that, in the recognition phase the detected traffic signs are classified and the output is displayed. Figure 2 shows interactions and information flow among different components of the system.

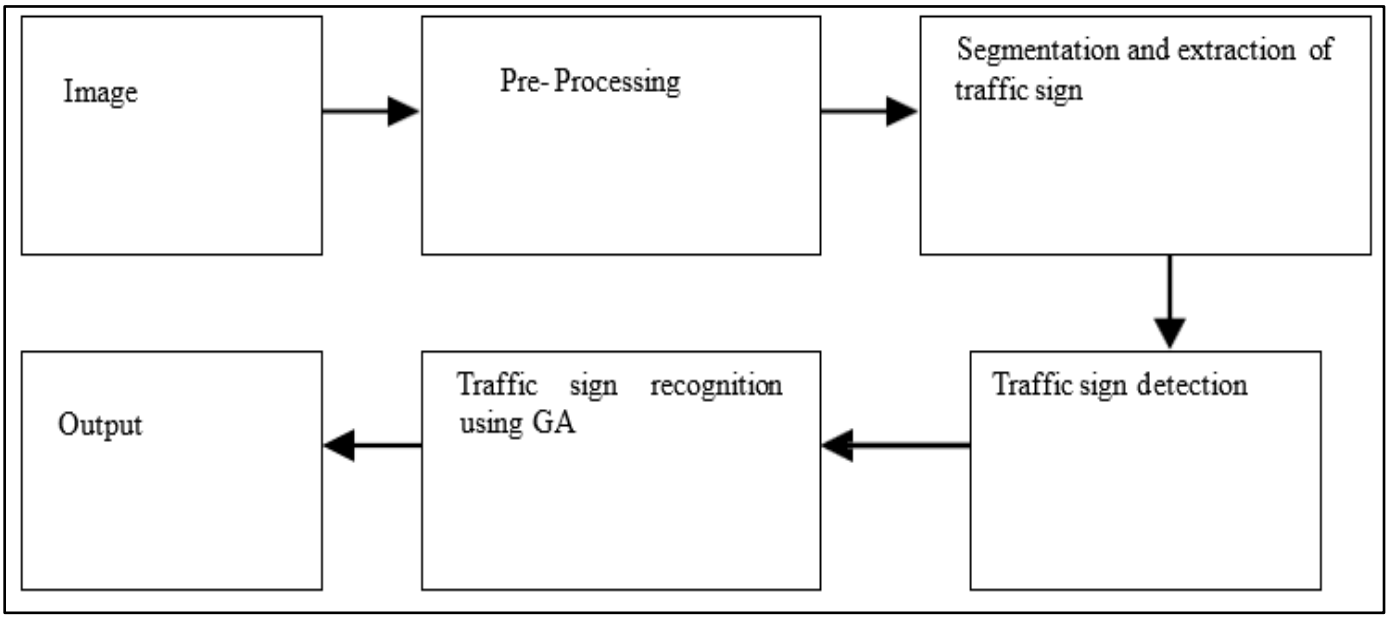

Fig 1 Detection and Recognition Process of Road Traffic Sign

The detection phase contains following operations such as pre-processing, feature extraction, and segmentation. The input image may consist of distortions due to noise, motion blur and low resolution. So, to reduce these types of distortions from an input image pre-processing is carried out. Here average filter of size [3 3] is used to reduce noise in input image. An average filter reduces the amount of intensity variation between one pixel and the next. Next step is to convert RGB image to normalized image. By using following formulae red and green components are converted to normalized red and normalized green components.

$$\text{Norm } R = R/(R+G+B) * 255 \quad (1)$$

$$\text{and norm } G = G/(R+G+B) * 255 \quad (2)$$

By comparing with threshold values image is converted into binary image, i.e. if the pixel value is in the given range, then it will write as 1 else it is 0. The range for normalized red component is from 93 to 145 and for green component 60 to 100. Hence at this stage we will get binary image.

Genes (Xg, Yg) are evaluated as we are using genetic algorithm for recognition. Now applying crossover function of genetic algorithm. Here three genes are considered m02, m11 and m20 for further calculations.

$$\text{Genes} = \tan^{-1}((2*M11)/ (M20-M02))/2 \quad (3)$$

Then Edges are extracted from the image using edge function of the MATLAB. It takes intensity or a binary image as its input, and returns a binary image of the same size as input image, with 1's where the function finds edges in an input image and 0's elsewhere.

In the next step slope calculation is carried out using formula

$$\text{Slope} = (Y2-Y1)/(X2-X1) \quad (4)$$

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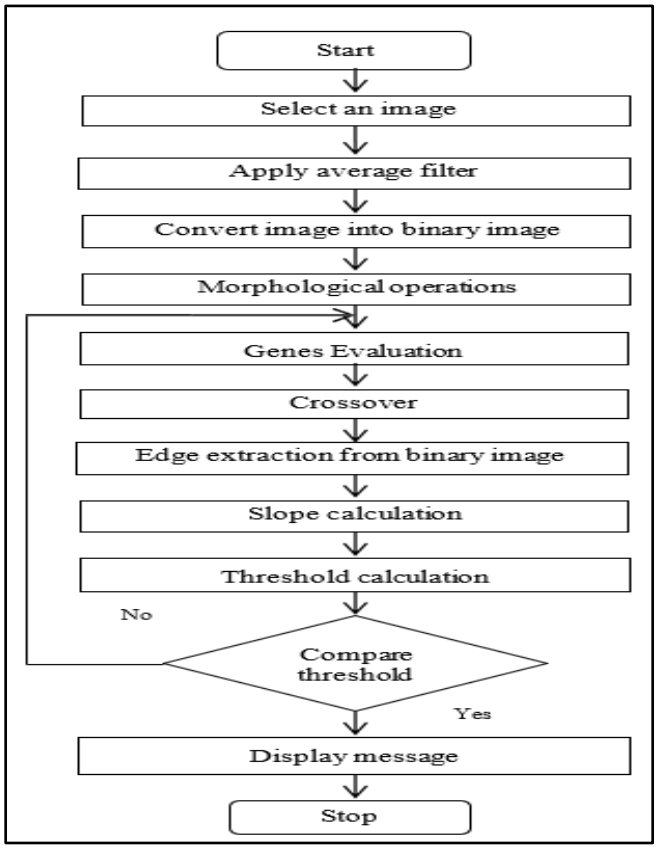

Fig 2 Flowchart for Road Traffic Sign Detection and Recognition System

Threshold value is calculated using graythresh function of MATLAB. Here using otsu's method threshold values are calculated. Threshold values are calculated at different levels such as 50/255, 100/255, 150/255 and 200/255.

This threshold value is used as stopping criteria for gene evaluation. By comparing with this threshold values traffic sign is recognized. If the genes are matched with this value gene evaluation is stopped and result is displayed i.e. meaning of the traffic sign.

IV. EXPERIMENTAL RESULTS

Resulting images at different stages of computation are shown in the figure 3 such as original colour image, grayscale image, and connected component at different threshold values. The edges are extracted from the given binary image to find out region of interest. Figure 4 shows the extracted edges from an image. Depending upon the threshold value genetic algorithm will classify the symbol. After recognition of traffic symbol, the message will be displayed. This message will give information about the meaning of symbol and which rule to be followed by the driver, such as Turn left, stop etc. figure 3 shows results for a triangular symbol named turn left.

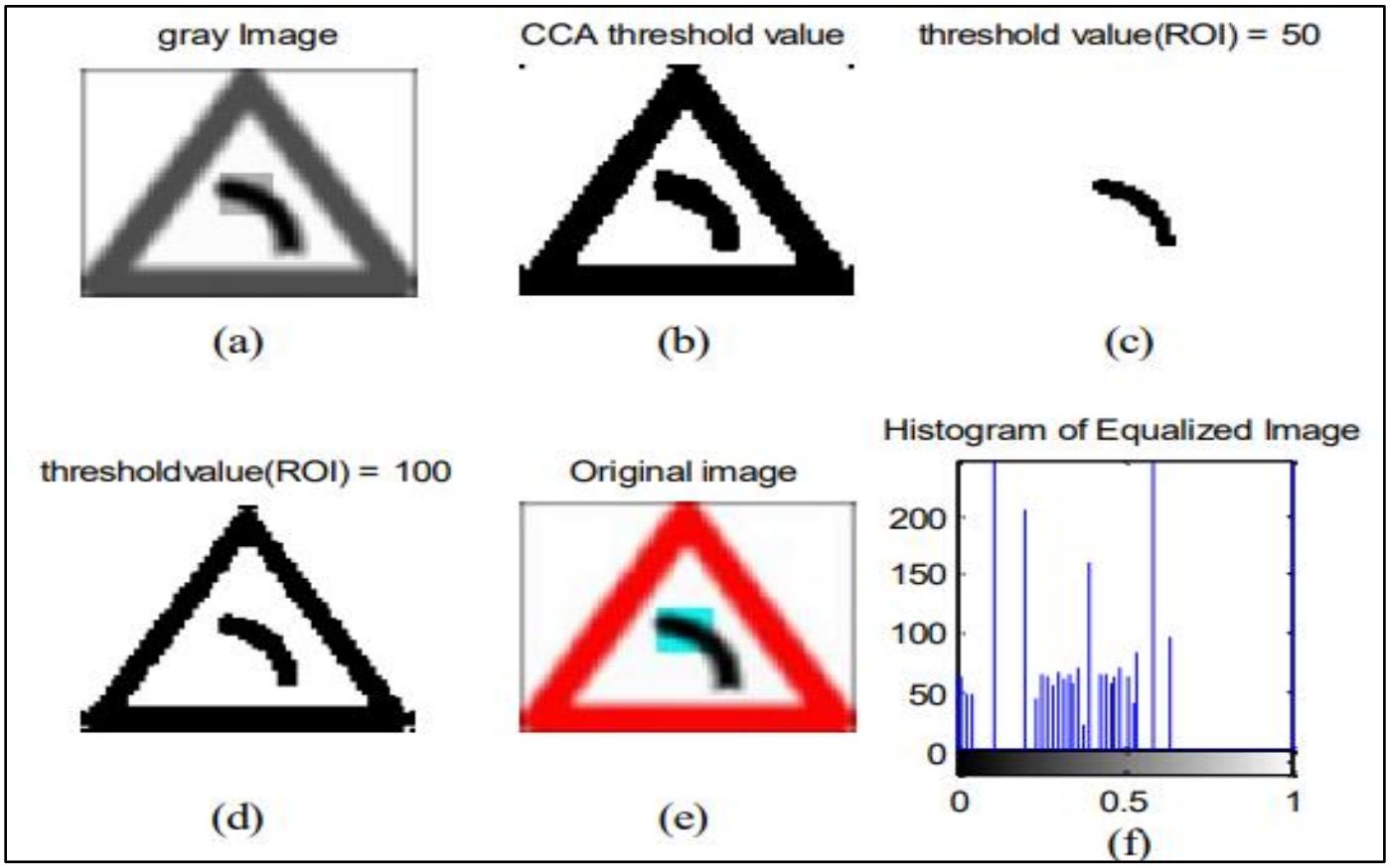

Fig 3 Result Images at Different Stages for Turn Left Symbol (a) Grayscale Image (b) CCA Threshold(c) Threshold = 50 (d) Threshold = 100 (e) Original Color Image with Centre of Gravity (f) Histogram of an Equalized Image

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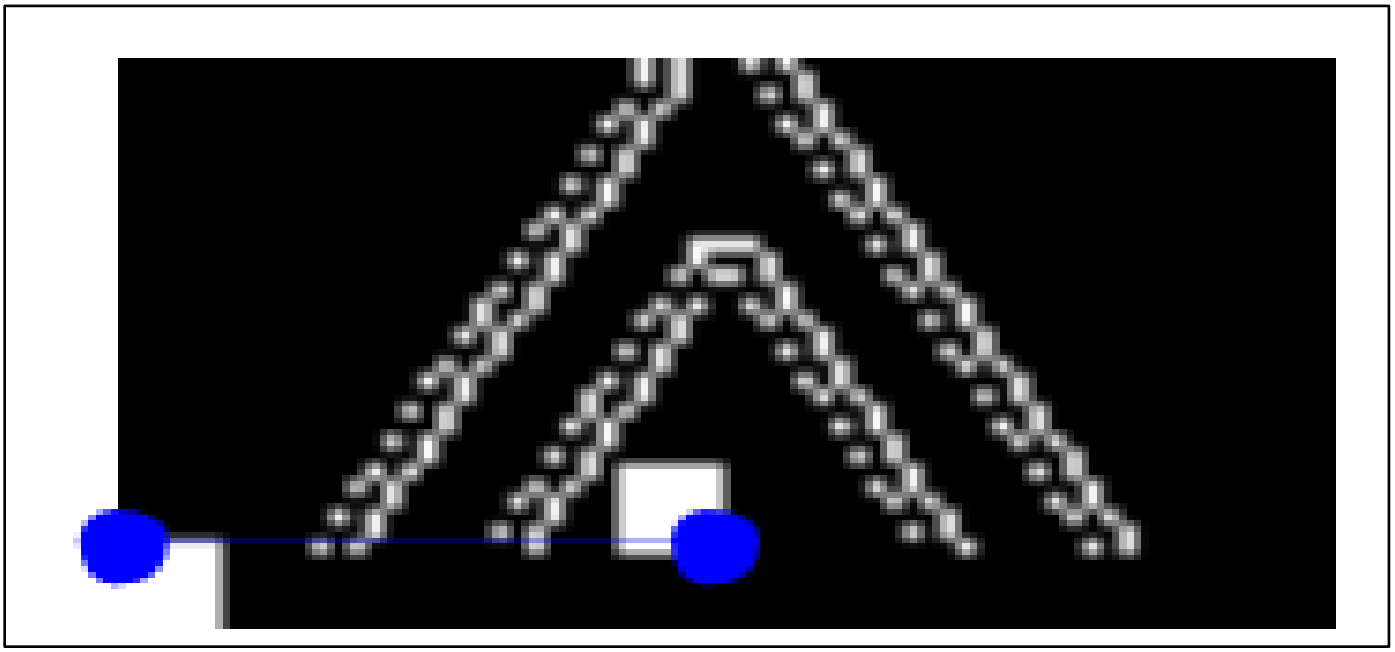

Fig 4 Extracted Edges from an Image

The result of classification is shown in the table 1 and the comparison between different classification methods is shown in the table 2. The parameters for comparison are accuracy and average time.

Table 1 Result of Classification

Samples	Correct Classified	False Classified
50 images	48	2
Percentage	96%	4%

Table 2 Comparison of Different Classification Methods

	Accuracy	Avg. Time (ms)
Support Vector Machine	87.8%	5.67
Neural Network	89.2%	600
Random Forest	94.2%	17.9
Genetic Algorithm	96%	2100

V. CONCLUSION

The road traffic sign recognition is studied by using genetic algorithm and connected component which are developed using MATLAB2014a. Also, the GUI model for this is obtained. On observing the results and comparing the parameters like accuracy and the processing time we have found out that the genetic algorithm gives much better accuracy than the conventional method. Hence conclusion can be made as the genetic algorithm for automatic road traffic signs recognition is implemented and studied, higher accuracy than the conventional method up to 96 % is achieved. The processing time is increased up to 2.75sec; hence the future challenge is to work on implementing hybrid algorithms such as GAs and Neural Network (NNs) in order to reduce the processing time.

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