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Car Driver Assistant System for Red Signal Detection

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ABSTRACT: In this paper, we are proposing Car Driver Assistant System for Red Signal Detection by proposing a new algorithm “CirCheck”for circularity checking of red signals depicted in digital images, which is around 3 times faster than Hough Transform based methods. The proposed Red Signal Recognition System has ability to detect and identify red signals even with bad visual artifacts those originate from some weather conditions or other circumstances. The developed algorithm in this paper, segments the required color influenced by the illumination of the environment, then reconstructs the shape of red signal by eliminating remaining segments and finally, identifies it. These three stages are called as “Segmentation”, “Reconstruction” and “Identification” respectively, within this paper. The proposed system gives a detection rate about 90% and is robust since it is less sensitive to weather conditions.

KEYWORDS: Red signal; pattern recognition; segmentation; identification.

I. INTRODUCTION

Designing smarter vehicles, aiming to minimize the number of driver based wrong decisions or accidents, which can be faced with during the drive, is one of hot topics of today’s automotive technology. In the design of smarter vehicles, several research issues can be addressed; one of which is Red Signal Recognition. In Traffic Signal Recognition systems, the aim is to remind or warn drivers about the traffic signals, beforehand. Since the existing signals are designed to draw drivers’ attention by their colors and shapes, processing of these features is one of the crucial parts in these systems.

Since safety becomes more important for customers, Red Signal Recognition becomes one of today’s research subjects aiming to improve safety of driving. While, they are presently developed just to warn drivers about some important traffic signs, in the future, these systems may take control of the vehicle under some circumstances. The input is mainly consisting of visual data during a drive. Accordingto those inputs, the driver performs the action of driving. Although, today’s technology cannot process all visual inputs as a human being, by a system focusing on some specified portion of this process, the workload of drivers can be decreased. Moreover, the resulting system is not influenced by some human related factors, such as tiredness, sleeplessness or so. Thus, the safety of driving is improved. For this purpose, Red Signal Detection systems are developed, mainly to decrease the probability of missing traffic signals on the road. The problem may seem to be easy to handle, at the first glance. However, since the process on a visual data is performed by human brain, based on all his experiences, it cannot be easy for a computer to perform the same process. Instead of those experiences, just some knowledge about distinctive features of traffic signs can be used. These features mainly consist of color and shape information. Although, this knowledge is not enough to separate traffic signs from other objects, the segmentation can be improved by the help of some intelligence while using the knowledge. For example, since the illumination is changing from time to time or from scene to scene, the color identification shall be performed accordingly. Additionally, since some traffic signs may be partially observed because of some conditions, the shape information shall be extracted despite of those conditions.

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II. Related work

In [2] authors used circle detection algorithm basedon a weighted minimum mean square error (MSE) formulation.The proposed algorithmachieves its robustness by operating in one step, using allpixels of the image (correctly weighted) and not using any thresholds.The detected circle is the solution of several weighted MSEproblems. The experimental results show thatthe proposed algorithm is quite robust and significantly faster thanthe Canny edge detector.

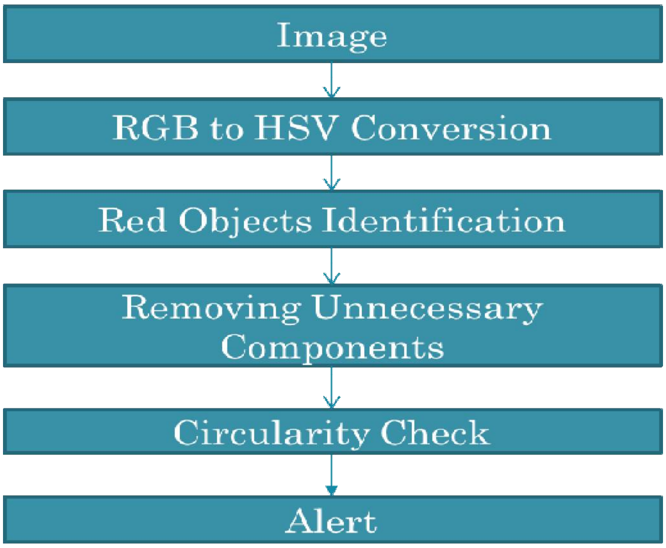
In[3] authors proposean algorithm which consists of a several steps in order to detect traffic signal,First, extract candidate pixels of signal lightfrom grabbed image, and cluster extraction result for separating each object. To determine theobject is signal light or not, applying 'circularity check' for each object. Looking around theobject, find frame of signal light. Finally, remove noise and increase reliability by 'robustfiltering'.This algorithm uses a virtual circle usingstandard deviation. Calculate standard deviation using pixels out of virtual circle. If that valueis less than threshold, consider that object as circle.

In [4] authors used aGPU parallelization to overcome the problem of too long computation time in Circle detection of Hough Transform. Two parallel methods are used based on Threading Building Blocks (TBB) and CUDA, by utilizing multi-core and GPU, the most time-consumingpart of circle detection is coped withparallelization.

In [5] author divides the whole method into two cases namely day and night.Proposed method uses different color spaces and detects and recognizes the traffic signals in a moving vehicle.The night scene uses RGB color space to detect traffic signal. Extract the objects in the scene which are of similar size as of the traffic signal. Then analyzes each candidate object for traffic light and see if it is red orgreen and compare it to its outer area. Finally checks for the rightmost signal among the selected signals. In the day scene, we use Cr frame ofYCbCr color space for detecting the red traffic signal and HSV in addition to YCbCr color space for detecting green trafficsignal. The overall process remains the same just the color space used for the traffic signal detection varies in night scenes and,red and green traffic light detection in the day.

III. PROPOSED ALGORITHM

A. *Flowchart:*



B. *Description of the Proposed Algorithm:*

Aim of the proposed algorithm is to detect and identify red traffic signal even with bad visual artefacts' those originate from some weather conditions or other circumstances.

Refer Fig.2. which is the sample input for proposed algorithm.

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Step 1:RGB to HSV conversion:

To derive minimum and maximum values for each H, S and V we extract three different RGB values from the red signal present in images.

The *R*,*G*,*B* values are normalized to change the range from 0..255 to 0..1 refer equation eq.(1), eq.(2), eq.(3)[7].

$$R' = R/255 \qquad \text{eq.(1)}$$

$$G' = G/255 \qquad \text{eq.(2)}$$

$$B' = B/255 \qquad \text{eq.(3)}$$

Find the minimum and maximum values from R, G and B and its deviation using equation eq.(4), eq.(5), eq.(6).

$$Cmax = \max(R', G', B') \qquad \text{eq.(4)}$$

$$Cmin = \min(R', G', B') \qquad \text{eq. (5)}$$

$$\Delta = Cmax - Cmin \qquad \text{eq. (6)}$$

Finally the H, S, V values are derived using equations eq.(7), eq.(8), eq.(9).

$$H = \begin{cases} 0° & , \Delta = 0 \\ 60° \times \left(\frac{G'-B'}{\Delta} mod\ 6\right) & , C_{max} = R' \\ 60° \times \left(\frac{B'-R'}{\Delta} + 2\right) & , C_{max} = G' \\ 60° \times \left(\frac{R'-G'}{\Delta} + 4\right) & , C_{max} = B' \end{cases} \qquad \text{eq.(7)}$$

$$S = \begin{cases} 0 & , C_{max} = 0 \\ \frac{\Delta}{C_{max}} & , C_{max} \neq 0 \end{cases} \qquad \text{eq.(8)}$$

$$V = C_{max} \qquad \text{eq.(9)}$$

Step 2:Red object identification:

From the HSV image red objects are identified with the help of OpenCV library. Refer Fig.3. for Results of this step.

Step 3: Removal of unnecessary components:

From the HSV image the unnecessary components are discarded with the help of contour area and new image is constructed which will help to reduce the final computation and results in faster execution.

Step 4:Circularity check:

In this algorithm, to detect Circle, we initially assume that the contour points form a circle (i.e. circle is present). To prove our assumption true or false, we will use this new proposed algorithm called Circle Detection Algorithm.

For Circle Detection Algorithm refer Fig.1.

The algorithm initially divides the circle points (i.e. the contour points) in 3 equal sized clusters (represented by 3 different colors). Let's say cluster size is***N*** (i.e. no of points in each cluster). Now, 3-points are selected one from each cluster points (P_{1i}, P_{2i}, P_{3i}) i.e. i^{th} point of each cluster. The mean is taken for these selected triplet, which will be the candidate centroid(center) ***Ci*** of the circle. Such ***N*** candidate centroids are calculated by iteratively considering ***N*** number of triplets, thus covering all points in circle.

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This Candidate Centroids found may have some deviation in them due to some outlier points caused by the noise in the image. Thus, to avoid this deviation, we again find the central tendency of these Candidate centroids, by taking mean of them. This Final Centroid, ***Cc***, will be very close to the actual center of the circle.

Now, we will calculate the distance of each point lying on circle w.r.t. to new centroid ***Cc***. This calculated distance will depict the radius of the circle. But again, this radius may deviate due to noisy image. So, we calculate the mean of this distance(***r***) taken from each point.

Now we will check the number of points in circle that satisfies the given threshold of the radius, θ_r. If this count satisfies another threshold called, Minimum Acceptable Points, θ_p, then we conclude that our assumption, that the given contour is Circle is true, else we conclude that the contour does not form a circle.

This Circle Detection algorithm will finally output that whether the circle is detected or not. Refer Fig.4. to see the detected circle shown with bounding box.

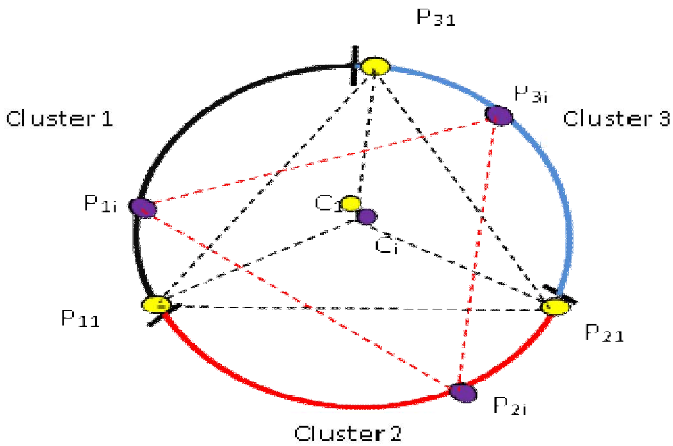

Fig.1. Model of Circle Detection

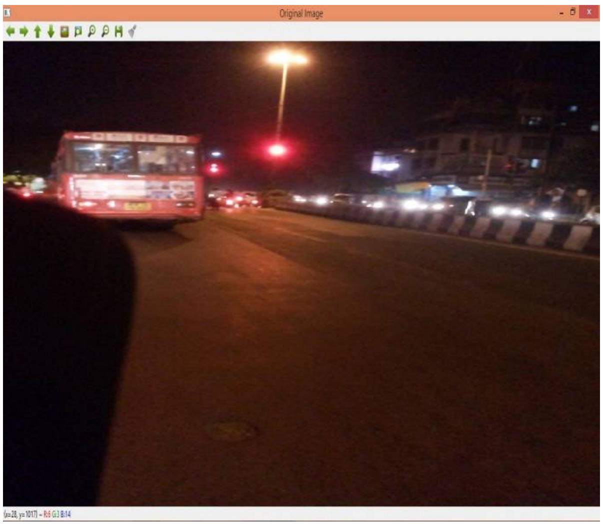

Fig.2. Sample input

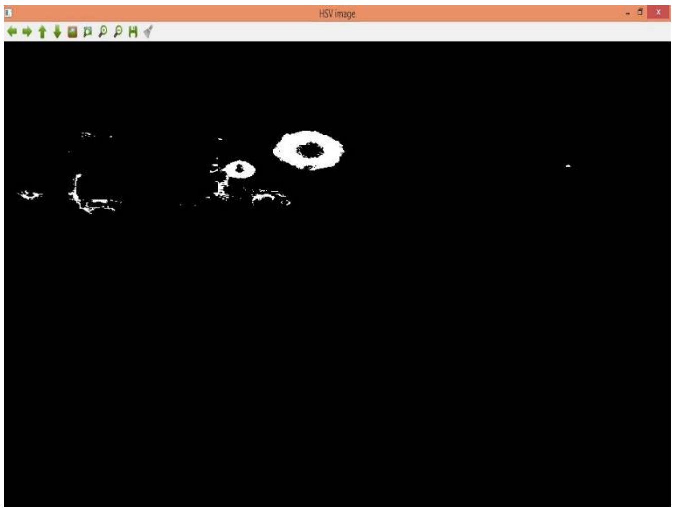

Fig.3. HSV output

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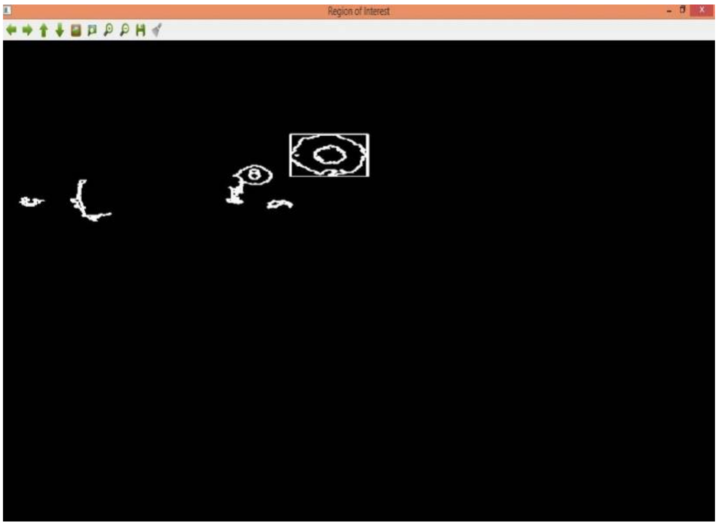

Fig.4. Region of interest gain from HSV image

IV. PSEUDO CODE

1. Initialize the cluster size, $N = \frac{\textit{total no.of points in contour}}{3}$
2. Divide the points into 3 cluster of size ***N***.
3. For ***i*** in ***1 to N***
   a. Find triplet consisting of ***i***th point of each cluster.
   b. Find the candidate centroid C_i for each triplet, by taking their mean.

4. Find final centroid $\mathbf{C_c}$ by taking mean of all candidate centroids.
5. Calculate distance of each point w.r.t. C_c using Euclidean distance formula. (this distance in case of circle will represent the candidate radius)
6. Calculate Mean of these distance denoted by ***r***(Radius).
7. Count the number of points that satisfies the threshold of radius θ_r w.r.t. Radius ***r***.
8. If count satisfies threshold called, Minimum Acceptable Points θ_p,
   then we conclude that Circle is present.
   Else,
   Circle is nor present.

V. RESULTS

A. *Databases: -*

Proposed algorithm tested and trained on images of resolution 768×1024.Two types of databases are used, Training Database and Testing Database. In both the databases images are captured considering different time constraints (ex. morning, afternoon, evening, night) as well as weather constrains (ex. sunny, rainy, mist, cloudy) to make system more accurate.

i. Training Database:-

Training Database consists of 100 images that have red signals on it.Training Database is used for calculating the range required for detecting the red colour from the image. The calculated range from Training Set will help in detecting all shades of red colour as the images captured at different time will consist of different values of RGB and HSV for red signals.

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ii. Testing Database:-

Testing Database consists of 300 images. Testing Database images are divided into two categories, images with red signal and without red signal. The Testing Database is used to measure the accuracy of the System. It is used for testing the system for images other than those in Training Set.

B. *Comparative study: -*

Proposed algorithm uses a new circularity check algorithm "CirCheck", whereas most of existing red signal detection systems relay on the Hough Transform based methods for circularity check. "CirCheck" algorithm works 3 times faster than that of Hough Transform.

"CirCheck" algorithm is best suited for checking whether the given connected component is circular or not whereas Hough Transform can identify all present circular objects in image.

C. *Experimental Result:*

Detection Rate: It is ratio of successful results to the total number of images in Testing Database. The proposed system provides the detection rate about 90%. This makes it acceptable for the real-time purpose

Specifications of machine on which algorithm is tested: -

OS	Windows 8.1
RAM	4 GB
Processor	Intel(R) core (TM)i3-2350 M
Processor Frequency	2.30 GHZ

Considering that proposed system would be used in vehicles, thus images captured by camera would be having some blur effect on images due to motion of vehicle as shown in above fig. 5 and fig. 7; still the proposed system will be able to detect the red signal as shown in fig. 6 and fig. 8.

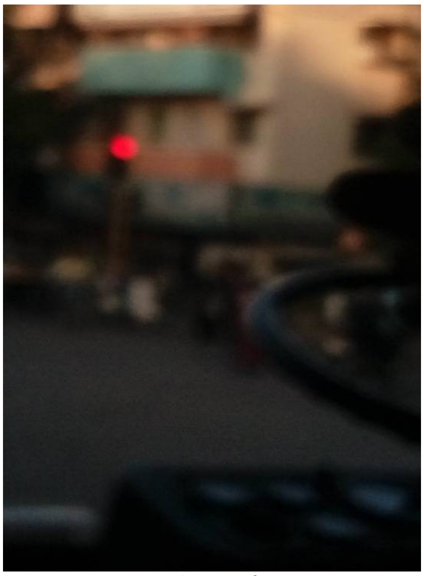

Fig.5. Captured image from Camera

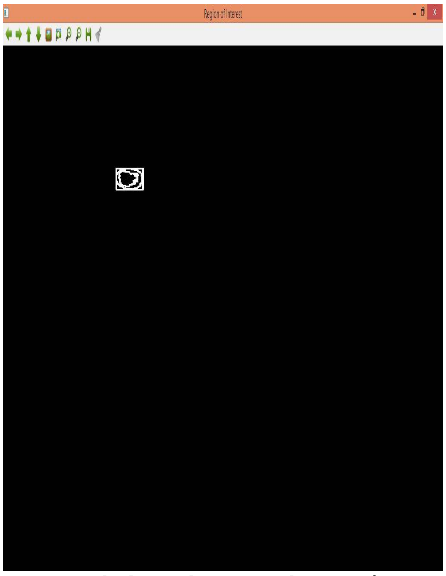

Fig.6. Circle detected in captured image of Fig.5

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Fig.7. Captured image from Camera

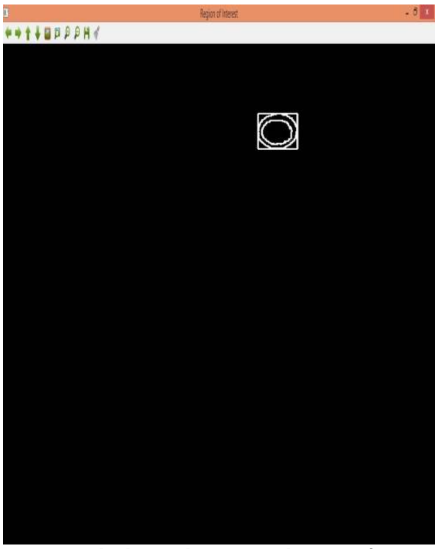

Fig.8. Circle detected in captured image of Fig.5

VI. CONCLUSION AND FUTURE WORK

The results showed that the proposed “CirCheck” algorithm performs execution 3 times faster than Hough transform based methods with the signal images of any weather condition. Given the candidate contours the “CirCheck” algorithm generates a result in 6.956ns whereas Hough Transform generates in 20.43ns.The proposed algorithm for Red Signal Detection provides overall detection rate about 90%.

The proposed algorithm “CirCheck” provides robustness and maximizes the accuracy of alerting system.This algorithm can be used with the low-price camera. Also, provides a fast recognition making it suitable for the real-time application.

Furthermore, this algorithm can be optimized to better accuracy than the existing approach and can also be implemented on hardware to be applied in the real time. GPU parallel execution using NVIDIA Jetson TK-1 board will enhance the performance of algorithm tremendously. The approach can be revolutionized by integrating to the driverless systems.

VII. ACKNOWLEDGEMENT

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BIOGRAPHY

P. S. Dhabe, has completed ME in computer technology from S.G.G.S college of engineering and technology, Nanded, Maharashtra, India in year 2002. He is presently pursuing his Ph.D. in systems and control engineering, IIT Mumbai. He is presently working as assistant professor in computer engineering at Vishwakarma Institute of Technology, Pune from 2005. He is principal investigator of research project funded by University of Pune, Maharashtra, India, titled "Database normalization tool". His areas of interest are database normalization, fuzzy neural networks and pattern recognition.

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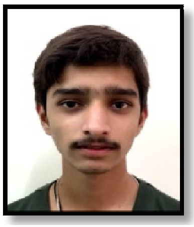

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