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Automatic Road Sign Recognition and Alerting on High Way

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Abstract – **This paper purposed a Road Sign Recognition system which can automatically detect and classified the traffic signs in traffic scene images acquired from a moving car and also alerting based on the recorded voice. It provides an additional level of driver assistance, leading to improved safety for passengers and vehicles. By alerting about the presence of road signs would reduce risks in situations of driving distraction, fatigue, poor sight and weather conditions. First it uses color based segmentation and then further refines the segments using two shape detection based techniques. A color description technique is used to extract the sign information from the segmented part which then finally classified by Neural network– which classify the detected patterns to known traffic signs using standard database the extracted shape and content features are utilized to train a Support Vector Machine polynomial Kernel which is later classified with the input candidate road sign shapes and contents respectively. An automatic voice alert system is also proposed such that a caution is given to the driven about the mandatory road signs that need to be followed and the new vehicle performance has been continuously improved and the study results relating to the safety of vehicle driving have also been continuously reported and demonstrated are also been discussed here.**

Keywords– **ARSR-Automatic Road Sign Recognition, DCI: Deceleration Control Interface, LCD Liquid Crystal Display, Speed Regulation, Support Vector Machine, IAV: Intelligent Automated Vehicle.**

I. INTRODUCTION

Road sign recognition has drawn considerable research attention in recent year's .Road signs have a direct impact on ones daily life as possible life threats can easily be formed due to a lack of concentration or ignorance. In addition, due to increased amount of possible threats on the roadside the impact of road signs on road users has considerably increased. During the last decades, many new road signs have been introduced according to the necessity and due to increase usage of the roads. Vehicle drivers specially need to learn to identify all road signs for road safety. For example drivers require having the knowledge of cyclist signs, pedestrian signs, obligatory signs and advisory signs etc. and ignorance of any sign can cause possible accident hazards.

Due to lack of literacy drivers may find difficulty in understanding the road signs, keeping this in mind the proposal of automatic voice (any regional language) alert inside the vehicle seems to be mandatory. The system can utilize other features of such as adaptive cruise control system to automatically drive the vehicle according to varying road speeds. Highway agencies and road maintenance engineers have the responsibilities to maintain the roads and the state of signposting which are vital for the safety of road users. It can be used for road sign inventory and inspection purposes. Damaged, occluded, tilted, rotated, color faded road signs can be recognized and used to reduce possible risks. The paper is organized as follows. In section II, a brief discussion about the properties of Road Signs & Challenges is presented. Section III will cover some details about the design and operation of our proposed project. Section IV contains conclusion.

II. PROPERTIES OF ROAD SIGNS &CHALLENGES

Generally road signs consist of three properties. Firstly they are represented by colors such as Red, Green, Blue, and Brown etc. Secondly they consist of particular shapes such as Circular, Triangular, Octagonal, Square patterns etc. The inner contents of road signs represent the third property, which vary depending on the application of the road sign. Due to presence of varying lighting conditions, scaling, angular rotation and obstruction, the perceptual color of a road sign appears to be different which makes it difficult to extract the accurate color information of road sign. The weather defined by rain, fog, snow etc., and time of the day Defined by day, dusk, night etc., play an important role in creating the above mentioned variations of illumination.

The size of a road sign as appearing in a scene has an impact on its detection and identification accuracies. Road signs that appear small will not be detected as the recognition of the color or shape of small objects is still a challenging issue for even the best computer vision algorithms. Therefore it is important to include a system functionality, which keeps track of a candidate sign from the point it first becomes visible in the scene until a recognizable size. Furthermore, the detection and recognition of a road sign in the presence of likely angular rotation is also a further challenging computer vision problem which needs to be addressed and resolved.

The detection and recognition of a road sign can also be affected by obstruction, i.e., due to the presence of objects in the field of view. This helps to overcome partial obstruction at a high success rate. To accommodate the recognition ability of all categories of road signs it is important to distinguish road signs not only by their contents but also by their color and shape information.

This approach is based on the Albert broggi's paper "Real Time road sign recognition" and is taken as the main reference [1] for this paper. Traffic sign recognition system works in real time, so time and accuracy are the main concerns. Taking these in view, this system uses a simple three steps based approach.

1. Color segmentation- separate red and blue segments from the image
2. Shape recognition and sign description– recognize possible traffic sign patterns and then do the color representation for proper description of sign
3. Neural network– classify the detected patterns to known traffic signs using standard database.

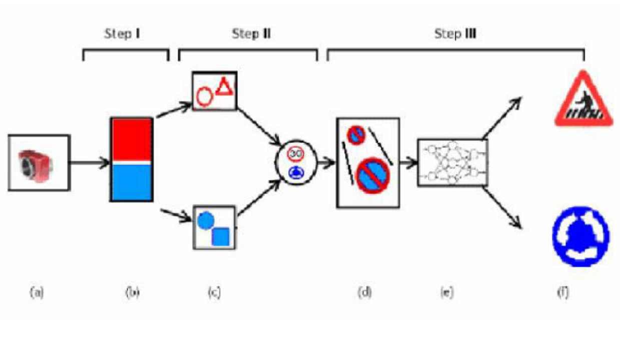

Fig.1. Algorithm flowchart (a) Image acquisition; (b) color segmentation; (c) shape recognition; (d) bounding box; (e) sign classification; (f) output

As similar to some other approach it uses color based segmentation as first step. It uses mono vision with a single front looking camera mounted on the wind shield of the car which can also be used for other applications like lane departure warning; therefore cost effective. Beside others above mentioned approach, it doesn't convert the camera data into any color schemes instead it uses the same RGB color scheme of data provided by the camera for color segmentation. Beside others it uses two shape classification techniques, simple and fast Boundary touching point's method and Pattern matching method, one after another in combination which removes more false positives, therefore results will be more accurate and take less time for further processing. This system can able to recognize almost all type of sign including speed signs, direction signs, restrictions signs, cautionary signs etc with red and blue in color. One more important feature is its low dependency on change in illumination conditions; therefore it is showing good performance in early morning, in afternoon, raining and snowing conditions and in late afternoon also.

The system also plays an important part in IAV (intelligent automated vehicle) by acting as a speed controller (regulator). Numerous researches has been conducted in the field of assistive robotics, and most studies on intelligent vehicle concentrated with developing autonomous behaviors of the mobility aid. Most behaviors exhibited in related literature are the ones concerned with detecting and avoiding obstacles, mapping a surrounding environment, planning safe routes, and navigating a doorway.

Advances of recent technologies in intelligent vehicle have already made enormous contributions in many industrial areas. There are many intelligent vehicle applications found in our society such as surveillance systems, quality control systems and AGVs (autonomous guided vehicles). Active safety and driver assistance systems share challenges with respect to environment and vehicle dynamic sensors as well as on vehicle dynamic actuators. The intelligent combination of both facilities, vehicular safety experiences and driver assistance systems, will be a key for the enhancement of future user benefit in passenger cars.

IAV provides the complete safety to the driver from all sides and make driving more simple, comfortable and most importantly safe. IAV vehicle uses many systems which help it become automatic vehicle by doing most of the things automatically without drivers support in which some system are based on sensors and some are vision based. Here are some vision based techniques like lane departure warning systems, Road sign recognition systems, pedestrian detection system, forward collision warning systems, blind spot detection system, night vision, intelligent head light control, rain sensing, headlight rotation and integration with side alert etc, which IAV uses to achieve its aim . Many developments are going on in this field.

Many companies are using Road sign recognition approach together with other system to develop a intelligent vehicle, uses a camera based Road sign recognition system with a lane departure warning system, where both system are using same camera. Road Sign Recognition warns drivers if they are speeding. Using monocular camera approach, they are detecting and displaying speed limit information through traffic sign on the vehicle front screen.

1. ARSR Algorithm

Disoriented, Camouflaged and Damaged sign board, sudden illumination variations in driving conditions, weather conditions like raining, night, sunny etc, speed of image sensor, variations in road signs, real time performance, these are the challenges we face while developing this ARSR system. Considering these challenges and real time implementation, we try to use simple and efficient methods in the algorithm.

2. Color Based Segmentation

The first step is the color based segmentation using the RGB color space. Average of red component and green component is computed for each pixel and develop a g-r histogram by representing the value of g-r (subtracting r value from g value) as "interval" and counting pixels for each interval Histogram- based thresholding is used to find optimal TR, because of computationally simplicity. A threshold value is selected based on histogram analysis and segmentation of image is done using this threshold into a binary image. Two-scan labeling algorithm is used to find out the connectivity between pixels and do labeling of connected component; which is an efficient method of labeling with respect to classical approach. A minimum pixel density and size is fixed and taking that as threshold, connected component (bounded regions) below this value are neglected. Overlapping regions where intersected area is more than 30% are combined together into one region containing area of both regions.

Sometimes same color signs are put in vertical or horizontal direction; in that case it's possible to get a bounding region containing two or more signs. So, to distinguish those regions, height by weight ration comparison is used. And then they are separated using histogram separation method

3. Shape Recognition

Two shape recognition methods are used in continuation one after another for further refining of false positive bounding regions. First one is Boundary Touching Points method which works as to find white and black pixels on particular 8 positions on the boundary of bounding box. Like for circular shape, there are four points where circular sign will touch the rectangular bounding box i.e. at mid points of every side of rectangular. So if it's possible to find white points (binary image get after segmentation) on the mid of every side of the bounding box and black points on the all four corners, then that bounding box is containing the circular shape region.

Fig. 1. For Circular Shape.

For triangular shape, there are also four points which can touch the bounding box i.e. midpoint of top of bounding box, corner of bottom of bounding box and midpoint of bottom of bounding box. So if it's possible to find white points on above mention four points of the bounding box and black points on remaining 4 positions, then that bounding box has triangular shape.

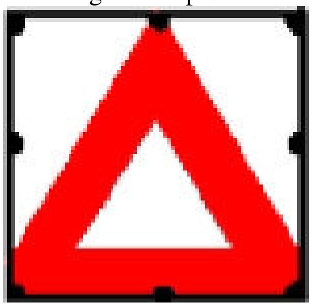

Fig.2. for Triangular Shape.

For rectangular shape as in case of blue signs, we can check for 8 points of the bounding box to get blue points i.e. mid points of all the sides and also four corners of the bounding box. So if it's possible to find white points on above mention 8 points of the bounding box, then that bounding box has rectangular shape.

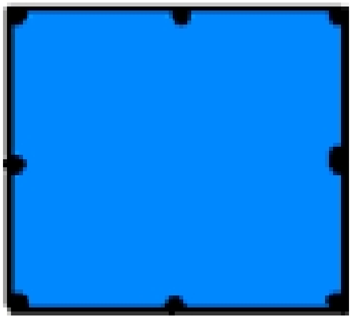

Fig. 3. For Rectangle Shape.

So in this way it can easily possible to distinguish between different shapes and also can remove false regions and even this method valid for blue signs also, so don't need to implement a different algorithm for blue signs. And here only 8 particular positions are checked, not all the points of bounding box. So this makes it very simple and fast method and it easily able to remove around 90 % false positives in most of the cases tested. So very few will go for next pattern matching method which is little more complex and time consuming. Therefore this method makes algorithm works faster.

Remaining regions are further double checked with second pattern matching method. In this, regions are classified based on matching white pixels with the standard templates for circle, triangle, inverted triangle, filled circle, restricted circle, filled rectangle. For every region percentage of matched pixel is found out with each template and region is assigned the shape with which it has maximum percentage of matched pixels. Maximum percentage should be greater than 65. For red color traffic signs, regions are classified into circle, filled circle, restricted circle, triangle and inverted triangle only. For blue color traffic signs, regions are classified into filled circle, filled triangle and filled rectangle only. Regions which are not satisfied above conditions are consider as false positive and are not considered (ignored) for further processing.

4. Description

Classified regions are then undergoes with description and representation process. HSV conversion of remaining regions is used in this case. Every region is normalized to 30*30 dimensions and average of V in HSV color space is calculated. As after shape classification, only internal information is used for next step of sign classification, so masking with zero matrixes is done only on the outer boundary of 10 pixel width of regions. Then taking value (V) and hue (H) part of HSV as threshold, a binary image is generated for each region.

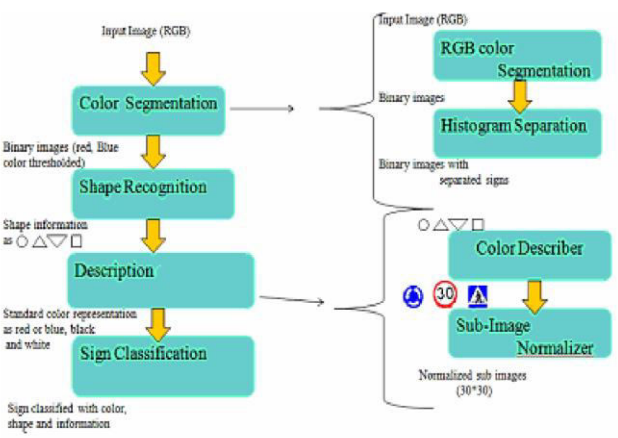

Fig.4. ARSR Algorithm flow chart.

5. Sign Classification

Feed Forward Neural Network is used for sign recognition. The network develops as follows: the input layer consists of 900 neurons which equals to the number of pixels both of the standard templates and normalized bounding boxes (30*30). Only one hidden layer is used and it has the same number of neurons as in input layer. In the output layer, number of neurons is equal to the number of signs included in the training set and corresponds to the probability (from 0 to 1) that the considered sign is the one corresponding to the output.
Five different neural networks are made depending on the different shape and colors e.g. for red circle, red triangle, red inverted triangle, blue circle, blue rectangle. All five neural networks are trained with standard signs by taking only the mid information converted into white color while boundary information removed by Making them black. Regions got after description and representation step are undergone testing with respective color and shape trained neural network and then regions are classified as traffic sign as the output of the neural network.

6. Speed regulation

DCI (Deceleration Control Interface) is used to provide the necessary information to the control system of the vehicle when ARSR act as a speed regulator. Color camera mounted into demonstrator vehicle observes the scene in the frontal area. The information of the sensor is fused and applied to a deployment algorithm for a braking system. In case of a dangerous situation the vehicle brakes automatically to decrease the vehicle speed and to increase the safety of the driver, pedestrian and vehicle.
In this case, the braking system installed on test vehicle is replaced with MANDO MGH-40 ESC plus to control vehicle deceleration via control area network (CAN) communication. The braking system incorporates deceleration control interface (DCI) for higher level system functions such as adaptive cruise control (ACC) and pre- crash safety (PCS). Fig.2.5 depicts control algorithm of DCI and input/output. As DCI receives multiple deceleration commands, deceleration coordinator selects desired deceleration based on the priorities and the vehicle status.
Once desired deceleration is established, feed-forward controller with a feedback loop controls vehicle deceleration by controlling wheel brake pressures. As the wheel brake pressures can be controlled by inlet/outlet valves and motor/pump of hydraulic unit (HU), deceleration control term is mapped to required solenoid currents and motor current, which are implemented by drivers of electronic control unit (ECU).

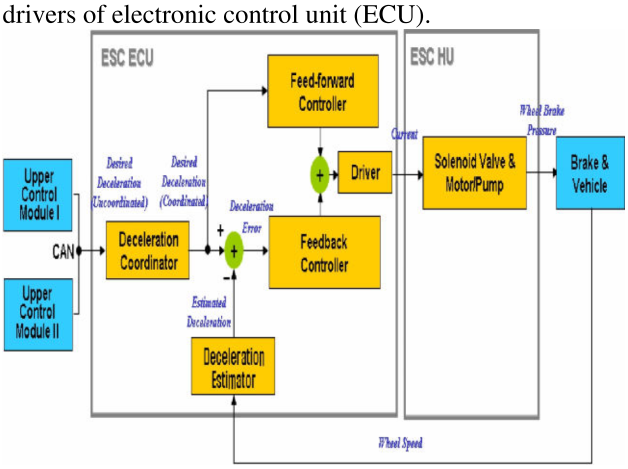

Fig.5. Control algorithm of DCI and input/output.

III. EXPERIMENTAL RESULTS

Experimental results are explained in sub four parts: Set-up & Scenarios, ARSR performance, and Speed regulation performance, audio alert.

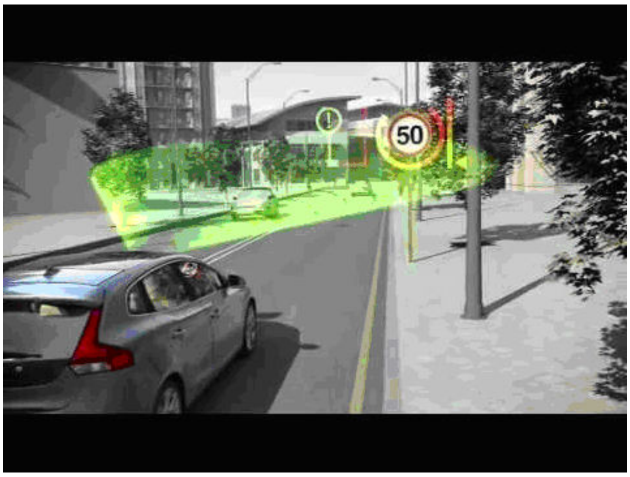

Fig.6. Image of Car Recognizing A Road Sign.

1. Setup & Scenario
To perform real time testing of ARSA system following set up is used.

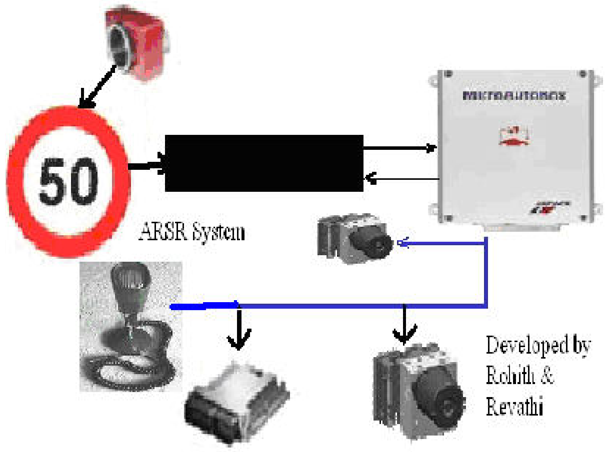

Fig.7. ARSA System.

It has four main parts

1. **Camera:** Allied GUPPY F-036C IRF
2. The AVT GUPPY F-036C (color) is ultra compact, space-saving IEEE 1394 WideVGA C-mount cameras, equipped with a highly-sensitive MICRON/Aptina 1/3 progressive Scan CMOS sensor. It works up to 60 Hz frequency with full resolution and capture a high f 70fps.
3. **ARSR Controller Desk:** This is ARSR algorithm processor in which ARSR code is embedded. It used the input as image frame from the camera and give output as an 8-bit message to the Micro auto box through CAN interface.
4. **Micro-AutoBox:** A microcontroller is used to control the other ECU's of vehicle by the message coming from ARSR controller through PCAN usb interface.
5. **Audio-unit:** A database of recorded voice is maintained, it is activated based on the proper recognition of the image. This unit is placed inside vehicle, near the driver seat.

2. ARSR Performance
ARSR system is tested for different type and color of signs like speed signs, direction signs, restriction signs, cautionary signs etc. with considering both red and blue colors. Here results are showing with taking 18 different types of sign in which 10 are red triangle, 3 are red circle and 5 are blue solid circle.. Three neural networks are created with these signs, one for red circle, second for red triangle and third for blue circle. Then real time images are captured from the camera at different day timings, weather conditions and system performance is tested using above neural networks.

Fig 3.2 Types of Signs.

No of Frames	No of Signs	True Recognition	False Recognition	Efficiency	Error
50	65	45	20	85	0.05

* Test data are collected from urban, countryside and motorway.

Table –I: ARSR Performance

Environment Condition	Car Speed	Average Recognition in Distance(meter)
Morning	65	30
	100	24
Afternoon	65	30
	100	24
Evening	65	30
	100	24
Rainy	65	30
	100	24
Snowfall	65	30
	100	24
Night (with street light)	80	25
	120	22
Night (with car head light)	80	20
	100	20

IV. CONCLUSION

This paper presents a new dynamically system that can successfully able to recognize the Roads signs at various weather conditions , We presented some of the challenges that it works well as speed controller to IAV vehicle. Other important characteristics of this system are incorporating a audio device for simultaneous action that has to take place when the road sign is properly extracted. Improving ASRS system performance in night time and with high speed and also large number of traffic signs used for training the neural network, are few works which need further advancement of the system. The design of a robust algorithm still remains an open research problem.

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