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Captiosus: Rear End Collision and Accident Alert System Using Video Processing

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Abstract: The population of the world is increasing and with this the number of vehicles on road is also increasing exponentially. Every household has at least 2 or 3 vehicles. This automatically leads to the rise the number of on-road accidents, in spite of government laws being enforced for the safety of the riders. This is because traffic rules are not being followed properly and many a times accidents occur with no fault of one of the driver. This is due to the fact that most accidents tend to happen when there is collision at the rear end. Hence there is a need of technology in vehicles which detects probable accidents by taking into account various factors around the vehicle and sending appropriate alerts. Keeping all this in mind, this paper proposes a system that uses image processing to detect the vehicles approaching from the rear end and alert the driver accordingly. Image processing is the analysis and manipulation of a digitized image, especially in order to improve its quality. We propose an algorithm which can detect vehicles from images with varying levels of brightness. If implemented in ITS (Intelligent transport system), this algorithm can revolutionize accident alert and detection systems and make them more effective.

Keywords: Rear-end collision; Collision Detection and Avoidence; Image processing; Intelligent Transport System.

I. INTRODUCTION

Year by year with the increase in traffic accidents, safety and human property are threatened. As there are severe con-sequences to traffic accidents, driver assistant systems (DAS) have been a popular research topic in recent times. Vehicle detection is an important and challenging part of the DAS. There are numerous causes for which an accident can occur, some of them being, use of mobile phone while driving, poor traffic management, lack of training institutes, driving while intoxicated, unskilled drivers, bad road condition and overloading. Rear end accidents mainly occur when the driver is being distracted and fails to keep a safe distance from the vehicles in the front. According to recent statistics, a major percentage of all traffic accidents involve rear end crashes.

Rear end crashes represents the highest rate of injuries that is 31% and also the highest percentage of property loss, being 33% and also show a rate of 5.6% fatalities when compared to other types of crashes. There have been constant efforts to develop an algorithm in the field of Intelligent Transportation Systems (ITS). An intelligent transportation system (ITS) is an advanced application, which aims to provide services relating to different modes of transport and traffic management. It enables various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

By establishing early vehicle detection and warning, it is possible to provide more time for a driver to take an appropriate action to resolve driving conflicts, and consequently to decrease the possibility of crashes. In order to achieve this, we propose an algorithm in which video can be divided into a number of frames each of which can be processed separately and a decision can be taken based on the output of each frame after being processed. Once this is done subsequent frames of a particular video can be further compared and more results can be inferred out of it. This algorithm makes use of a single color model and is further processed into a binary image as it is easier to separate background information in such images. Further, the noise also has to be removed from the images for improved detection.

This paper talks about processing single frame (image) using MATLAB software and has to be later implemented for videos and later to a live feed. Artificial intelligence utilizes software program that analyze the images from the video to recognize vehicles and sends an alert if it detects a vehicle breaking a “rule“ set by the programmer depending on his needs. This type of AI is known as rule-based because a human programmer must set parameters/rules for all the things that he must be alerted for.

II. RELATED WORKS

Installation of 4 television cameras at a curved area on an expressway where vehicle accidents frequently occur is proposed by A.TSuge and H.Takigawa and H.Osuga and H.Soma and K.Morisaki. The method was found to be effective in detecting accidents and stopped vehicles, and sending alarms to following vehicles, thereby preventing secondary accidents and jams. The method was found to 90% accurate by considering the various traffic parameters. But the major disadvantage of this system is that it is applicable only to applicable only to curved areas in an expressway [1].

A video image detector system is proposed by Jung Lee. This method uses tracking techniques shadow and occlusions overcoming and also considers no lighting at night. Various parameters such as traffic information, volume count, speeds and occupancy time were derived and taken under kaleidoscopic environments, and an accident detection system using vehicle tracing stream is proposed. Real world problems such as shadows, occlusions and vehicle detection by night time is addressed by this system. But the system does no work in all environmental conditions and land sites [2].

Wei Zhana and Xiaolong Ji have proposed a moving vehicles detection algorithm based on optical flow. The detection accuracy of optical flow is higher than that of temporal difference and image subtraction with background, so optical flow algorithm is more suitable for multiobjective moving. The effect of light change can be avoided by this method, but the system is still affected by light change of surroundings [3].

Fahim Bin Basheer, Jinu J Alias, Mohammed Favas C, Navas V, Naveed K Farhan and Raghu C V have attempted detection of accident through three parameters-acceleration/deceleration, tilt of the vehicle and the pressure change on the body of the vehicle. An apt algorithm was developed based on these 3 parameters which detects accidents with a reasonable success rate. However the system has a lot of potential for improvement such as the accident rescue operations and many resources are required to implement the system [4].

A Real Time Traffic Accident Detection System (RTTADS) using Wireless Sensor Network (WSN) and Radio-Frequency Identification (RFID) Technologies is created by Hossam M. Sherif, M. Amer Shedid and Samah A. Senbel. Sensors installed in the vehicle detect the various parameters just before the accident and send it to a monitoring station, which can then take specific actions. Accidents can be detected in real time but the proposed system is not cost effective [5].

A system that estimates the deceleration of vehicles due to breaking is proposed by Pradhan Suvendu Kedareswar and Venkatasubramanian Krishnamoorthy. The system displays the breaking intensities by using an array of LED’s. The breaking intensities are monitored and communicated to the vehicles that are following it in lambertian range of IR transmitter modules to avoid any collision pre-hand. The system is quick in response in terms of response time and has increased efficiency as it is independent of any external infrastructure and it is lower in cost. But only vehicles in the Line of sight or Lambertian range are considered and the range of the system is also very small [6].

D. Lee and H. Yeo have applied a Rear-End Collision Warning System for mitigating collision risk to the front of vehicles, under traffic conditions. A Multi-layer perceptron neural network based rear-end collision warning algorithm (MCWA) has been developed and evaluated through a comparison between the conventional algorithms such as Time To Collision (TTC) and Stopping Distance Algorithm (SDA). The system can also be used for rear end collision detection. While the system shows noticeable performance improvements for predicting the potential rear-end collision by detecting the critical deceleration rate in advance, it requires a considerable learning time depending on the characteristics of input data [7].

An IoT system solution that notifies a main headquarters when an accident occurs and also pinpoints the geographic location of the accident is conveyed by Elie Nasr, Elie Kfoury and David Khoury. The system also provides some ancillary information regarding the accident. The system makes use shock sensors to detect accidents. Results of the system simulation has showed that this solution provided many advantages compared to traditional systems namely, minimizing injured passengers interaction, providing basic medical information to rescue teams, recognizing exact and accurate accidents locations, and facilitating the routing process. Also the system was shown to be robust by reliability tests. However the heavy load on the servers due to a large geographical area is not considered by the system [8].

A vehicle break behaviour detection method by using a camera or mobile device fixed on the windshield of vehicles is proposed by Xueming Wang, Jinhui Tang, Jianwei Niu and Xiaoke Zhao. The brake behaviour detection in includes two procedures, brake lights region detection and brake behaviour decision. For the first procedure, threshold segmentation and proposed horizontal– vertical peak intersection strategy is used to filter and generate the credible rear-light regions of the front vehicle in the YCrCb colour space converted from the original RGB colour space. For the second procedure, the sophisticated SVM classifier is trained to detect the brake behaviour of the front vehicle. The end results of the tests has shown that the system can predict the breaking behaviour of vehicle ahead successfully. But the system fails to accurately work in case of red colour vehicles [9].

Mahdi Rezaei, Mutsuhiro Terauchi, and Reinhard Klette propose a real-time monocular-vision-based techniques for simultaneous vehicle detection and inter-vehicle distance estimation. This is a collision warning system which detects vehicles ahead and assists a distracted driver, prior to occurrence of an imminent crash. The algorithm is able to detect vehicles in both short and long range, and also in both day and night conditions. However the distance estimation is done using only monocular based vision which is inefficient [10].

Deng Yuan Hung, Chao Ho Chen, Tsong Yi Chen, Wu Chih Hu and Kai Wei Feng propose the use of a single lens video camera for vehicle detection and inter-vehicle distance estimation, for driver assistance in urban and suburban roads. The distances between the host and its front vehicles are estimated based on the locations of detected vehicles and vanishing point. Results show that up to 94.08% detection rate can be achieved by the system. The system is highly feasible but the disadvantage of this system is that only detection of vehicles and inter vehiclular distance is performed, where as collisions on vehicles is failed to be detected [11].

III. PROBLEM STATEMENT

It has been implied in the literature survey that, all the previous works with reference to this topic either involves a system in which, the mechanism used to collect real time data such as camera, sensors etc. are all placed external to the vehicle, in places such as in a curved area on an express way, lanes and roads or are placed in front of the automobiles to help in driver assistance, vehicle tracking and detection. Systems proposed and implemented so far, almost inconceivably enable us to detect collisions and have no protocols in place if in case an unavoidable collision take place, beside most of the systems give attention to front end collisions. Rear end collision detection systems are scanty, and use techniques such as detection of breaking intensity along with communicating to other vehicles, application of neural networks etc. The problems that are faced by existing rear end collision systems are detection of collisions while turning, problems of shadows, pedestrians, problem related to distracting notification alerts, detection under different light conditions and night time collision detection and problem of working under damaged conditions when an actual collision happens. The existing systems also do not incorporate an interface, in such manner that the system can be personalized by the user.

IV. PROPOSED WORK

The architectural diagram of the proposed system is shown in figure-1. We propose a portable system that is attached to any vehicle to address the above stated problems; this system is an improved rear end collision system which is based on image and video processing. Using image and video processing the system is able to send the audio alerts and can detect whether the vehicles approaching from the rear end are moving at dangerous speeds or not. If the speed of the user is less than a certain threshold value the system should not send any alerts or it should be switched off. The system is adaptable to the users speed at all time, it should turn on again only if the speed of the user rises above a threshold value set by the user. It is proposed to work in all conditions that includes urban/suburban roads, highways and city traffic and can function in all lightening conditions such as daytime, dawn/dusk and night-time.

When an actual collision occurs it should be able to send emergency alerts to the nearest health centre and guardians of the user. It should also be able to work in damaged conditions, to allow the user to personalize the device for a particular vehicle and liking, the system should have an easy to use interface. The system is represented as shown in the figure. To detect the traffic, a web camera is used which sends the live feed to video processor that houses the algorithm. Based on the traffic detected the instructions are given to speakers to speak out alert messages. To help the driver take turns, particular section of the road is diagnosed on traffic based on the indicator. To avoid continuous alarms during traffic signals the algorithms get activated or deactivated based on the wheel speed and also a message can be sent to a predefined location or device that are sensed by crash sensors if in case any accidents occur.

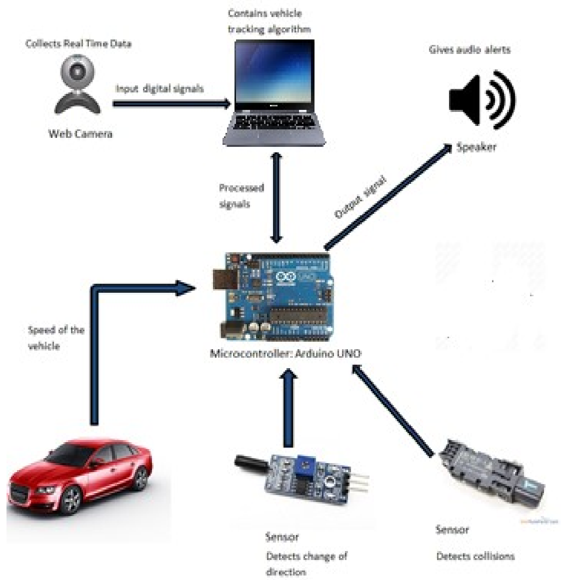


Fig 1. Architectural diagram of Captiosus

V. ALGORITHM USED

The entirety of the algorithm can be divided into 4 sub-parts

1. Image Acquisition
2. Color Preprocessing
3. Conversion to Binary Image
4. Noise Removal

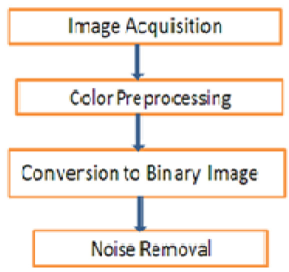


Fig 2. Steps used in the algorithm

A. Image Acquisition

Firstly data has to be collected for the input of the algorithm to process. As we are using image processing and not making use of video directly, we take only certain number of frames out of the video. It is better to consider more number of frames for higher accuracy. These frames should be of various traffic conditions like that of empty roads, vehicles nearer to the camera, away from the camera and vehicles at a moderate distance from the camera. This variety of images gives a clearer picture of different values of brightness, hue, saturation etc. that exists in different traffic conditions. We have also considered images from different times of the day so that the system works efficiently in all cases.

B. Colour Pre-Processing

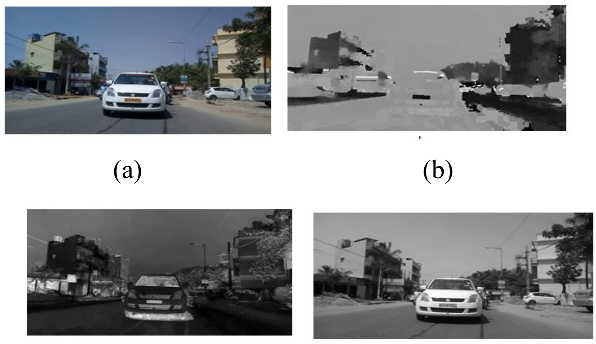
Pre-processing is a very important part of image processing, the aim of which is to improve the image data by either suppressing unwanted distortions called noise or enhance certain image features, important for further processing of the image. For the purpose of image pre-processing, we have converted the acquired image data to different colour models. A colour model is an abstract mathematical model describing the way colours can be represented as a finite ordered list of numbers, typically as three or four values or colour components. When this model is associated with a precise description of how the components are to be interpreted (viewing conditions, etc.), the resulting set of colours is called colour space. To suit the requirements of the algorithm for rear-end vehicle detection, specifically the HSV colour model is selected.

The HSV colour model is an alternate representation of the standard RGB (Red, Green and Blue) colour model. HSV stands for Hue, Saturation and Value which are the individual components of the model. This colour space describes colours (hue or tint) in terms of their shade (saturation or amount of grey) and their brightness value. Hue is the colour portion of the colour model, and is expressed as a number from 0 to 360 degrees. This is shown in the table-1.

Table 1. H-Component colours and their respective components

Colour	Angle
Red	0-60
Yellow	60-120
Green	120-180
Cyan	180-240
Blue	240-300
Magenta	300-360

Saturation is the amount of grey in the colour, from 0 to 100 percent. A faded effect can be had from reducing the saturation toward zero to introduce more grey. However, saturation is sometimes viewed on a range from just 0-1, where 0 is grey and 1 is a primary colour. Value works in conjunction with saturation and describes the brightness or intensity of the colour, from 0-100 percent, where 0 is completely black and 100 is the brightest and reveals the most colour. The HSV colour space is used when selecting colours for paint or ink because HSV better represents how people relate to colours than does the RGB colour space. Figure-3 shows the HSV components of an image.



(a) (b) (c) (d)

Fig 3. (a) RGB image (b) H-component of the image (c) S-component of the image (d) V-component of the image

Only one of the components was used in the algorithm. In order to conclude that HSV model is more suitable, we converted and segregated the collected images into different components of various models, using MATLAB.

C. Conversion to Binary image

In this part of the algorithm we converted the images from saturation model to binary images. In a binary image each pixel assumes one of only two discrete values corresponding to on (1) and off(0). This is shown in figure-4. Analyzing any image this way makes it simpler to distinguish its structural features. In this case, it becomes easier to separate the vehicles from the background. In MATLAB, a binary image is represented by uint8 or double logical matrix containing 1's and 0's representing white and black respectively.

First we tabulated the minimum and maximum values of the saturation in the road region in each image and found the range of each image on averaging it. The average value fell between 12.88 at the lower end and 30.26 at the higher end.. All the pixels within the range were made black and those outside the range were made white.

Fig 4. Converted binary image

D. Noise Removal

In electronics, noise is an unwanted disturbance in an electrical signal. Noise generated by electronic devices varies greatly as it is produced by several different effects. In image processing noise usually takes the form of random variation of brightness or colour information in images. This noise is usually electronic noise that can be either generated from the sensors and circuitry of the digital camera or Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Noise in images is an undesirable by-product of the captured image that distorts and disrupts the desired information. The different types of noises that can occur in digital images are Gaussian noise, Salt and pepper noise, Shot noise, Quantization noise (uniform noise), anisotropic noise and Periodic noise.

In our proposed algorithm for vehicle detection, all other information in an image other than approaching vehicular information is considered to be noise. This noise could be responsible for obscuring the desired information regarding incoming vehicles and also setting off false alarms. Hence noise removal for the proposed algorithm is of utmost importance.

Noise in images usually appears as a high frequency signal, and hence filtering techniques are typically employed for noise reduction in image processing. But since in the proposed algorithm the procured image is converted to a binary image, conventional filtering methods cannot be used as both vehicular information and noise is converted to binary bit 1. Therefore Erosion and Dilation techniques are employed for reduction of noise in the said algorithm.

First step of noise removal in the algorithm is Erosion. The basic idea of erosion technique is similar to soil erosion, it erodes away noise along with the boundaries of the object. Erosion removes the white noises in the binary image, but it also shrinks the object. Therefore in this case of noise removal erosion is followed by dilation. Dilation is just the opposite of erosion. Dilation increases the white region in the binary image and hence has the effect of retrieving the eroded vehicular information. Since is the noise is completely eliminated in the previous step of erosion it will not be brought back due to dilation but the object area increases. Erosion and Dilation of an image is shown in figures 5 and 6.

Fig 5. Eroded Image

Fig 6. Dilated image

VI. RESULT

The simulation of the proposed system was conducted using Simulink tool in MATLAB software. Real time data is collected using the camera on a mobile device with sufficiently high resolution. The data collected from the camera was fed to the system containing MATLAB via a wireless Wi-Fi connection. The performance of the system was also analysed using the MATLAB software. The performance analysis of the system is as follows: The system as given the affirmation to function based on the speed of the user vehicle. The system activated only when the speed exceeded a threshold of 30km/h. Different zones were defined to identify the position of the vehicle, as shown in the figures 7, 8 and 9.

Fig 7. Vehicle in Danger zone

Fig 8. Vehicle in Intermediate zone

Fig 9. Safe zone

The system was accurate to a factor of 90% in determining whether the rear end approaching vehicle was either in the safe, intermediate or danger zone when tested on road with actual traffic conditions during both daytime and night time. This the result was displayed as shown in the figure-10.

The user was also notified based on the position of the approaching vehicle. The notification sent to the user were of 3 types

1. No notification
2. A simple beep
3. Voice notification

The user was sent no notification if the position of the vehicle was in the safe zone. If the position of the vehicle was in the intermediate zone, the user was notified with a beep and in the vehicle was positioned in the danger zone, then the user was notified with a voice message. This method was employed so that the system would not create a sense of disturbance to the user.

In the situation that the user wanted to shift lanes, the system was designed to crop the right or left side of the frames captured, based on the activated indicator of the user vehicle. This was again tested on actual road conditions and the system was found to perform efficiently.

The system captures an actual crash by means of a crash sensor. When an actual crash happens the system identifies it and sends a g-mail immediately to both the guardians of the user and a nearby emergency center.

The system timing and efficiency was calculated by using the Simulink tool on MATLAB. The timing of the system was found to have a delay of 1s, which is assumed to be with in error range and the system efficiency was found to be 90%.

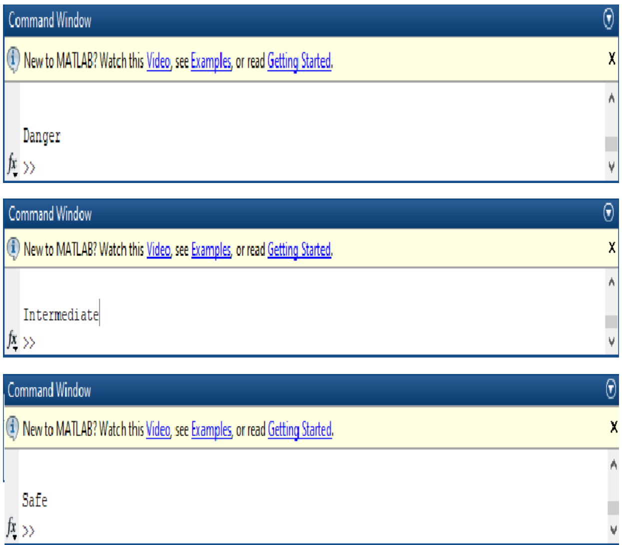


Fig 10. Messages displayed based on vehicles position

VII. CONCLUSION

This paper presents a overview of our solution proposed to address the issue of rear-end collision. The novel idea is based on image processing. The solution involves the use of a portable system, that can be attached to the rear-end any vehicle. The system is designed to collect real time data via a camera and uses an algorithm to accuratley and efficiently detect rear-end approaching vehicles and alert users of any dangerously approaching vehicles. The puropose and motivation behind the design of the system is to reduce number of rear-end collisions occuring on road by the use of the system and prevent any damge or death from occuring. Future scope for the proposed solution could to use high end grahic processors with muli-threading capabilities to increase the speed of operation of the system. The system can also be made into a more compact unit and artificial neural networks and machine learning can also be integrated to make slight adjustments to the algorithm where ever and whenever required spontaneously and instantaneously.

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