A Review Paper on Collision Avoidance System for Automobiles

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Abstract: **Collision Avoidance systems are one of the great challenges in the area of active safety for automobiles. Their function is to allow the driver enough time to avoid the crash. The frequency at which traffic collisions are reported is highest in India.The problem of road accidents is needed to be stopped at an early stage otherwise they might cause huge problems. This paper reviews various developed and proposed mechanisms of collision avoidance systems of automobiles. Collision avoidance systems include sensors which sense the obstacles in the path and make vehicle to come to a stop. A review of three algorithms namely those of Honda, Mazda and Berkeley reveals that all these collision avoidance systems are based on intelligent sensor technology, which automatically intervene to initiate actions designed to avoid collision. Each algorithm is adapted to a particular situation.**

***Keywords*—** **Collision Avoidance, Automobiles, sensors.**

1. INTRODUCTION

In the year 2014 nearly 75,000 people were killed in road accidents[1]. Over 81% of these victims were males, according to a report prepared by road transport and highway ministry. The report also reveals that the age group of 16-35 years accounted for 54% of the total victims and the rest 46% were of the age group 35-64 years. According to the latest estimate of World Health Organization (WHO)" nearly 3.4 lakh youngsters die in accidents all around the world". This shows that there is an immediate need to pay attention to make young people more aware of road safety issues.On the other hand, at the same time the total number of accidents can be reduced by installing safety systems in vehicles. However, it was found that many traditional safety measures are losing their effectiveness in the higher density traffic as these systems do not reduce probability of accidents, but are meant only to prevent or reduce the injury to the driver and passengers in case of an accident. Thus we need collision avoidance system or driver assistance system to make the vehicle stop within a safe zone on detecting any possibility of an accident.

A collision avoidance system works in following manner: [2]

- A sensor installed at the front end of the vehicle constantly scans the road ahead of vehicle for obstacles that could cause collision.
- When an obstacle is detected, the system determines whether the vehicle is in danger of getting crashed,
- If so, brakes are applied automatically to stop the vehicle to avoid crashing against obstacle.

In this review paper we are surveying these collision avoidance systems and making conclusions out for further study.

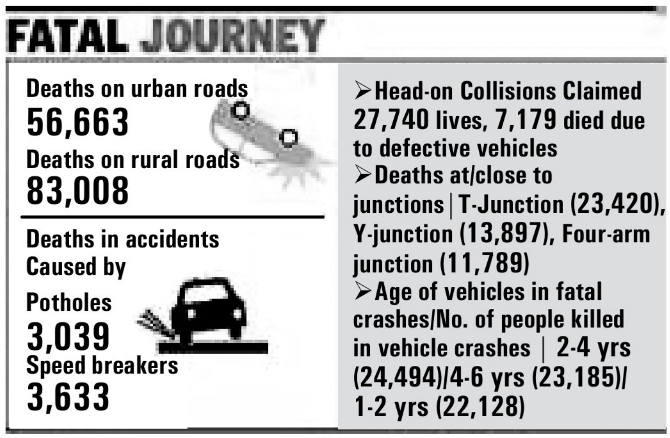
FATAL JOURNEY
Deaths on urban roads
56,663
Deaths on rural roads
83,008
Deaths in accidents Caused by
Potholes
3,039
Speed breakers
3,633
➢Head-on Collisions Claimed 27,740 lives, 7,179 died due to defective vehicles
➢Deaths at/close to junctions | T-Junction (23,420), Y-junction (13,897), Four-arm junction (11,789)
➢Age of vehicles in fatal crashes/No. of people killed in vehicle crashes | 2-4 yrs (24,494)/4-6 yrs (23,185)/ 1-2 yrs (22,128)

Figure 1: Article from Times of India 2013-14[1]

2. LITERATURE SURVEY

There are many systems which have been proposed for driver assistance to avoid collisions; such a system could help in critical situations and improve road safety. Such systems continuously monitor driver activity and surroundings of vehicle for early detection of potentially dangerous situations using intelligent sensor technology. Ina critical situation, the system warns the driver, and, if necessary, intervenes automatically to avoid collision. The following terms have been used in the rest of the paper:

Host vehicle – the vehicle equipped with the collision avoidance system and following another vehicle moving in the same direction.

Lead vehicle- the vehicle in front of the host vehicle and moving in the same direction.

V_H – velocity of host vehicle,

V_L – velocity of lead vehicle,

R_R – is the range rate, i.e., the relative velocity between the two vehicles ($R_R = V_L - V_H$), *A. Mazda Algorithm*

The Mazda overriding algorithm considers a hypothetic case, as shown in Fig.2[3]. First it assumes that initially both the host vehicle and the lead vehicle maintain constant speeds V_H and V_L, $V_H > V_L$ respectively. Then the lead vehicle starts to brake after time t_2 at a deceleration of $-\alpha_2$, while the host vehicle starts to brake after an additional time of t_1 at a deceleration of $-\alpha_1$, and this continues till both the vehicles comes to a full stop. The overriding range R_0 is computed as the minimum range needed at time 0 to allow the scenario to happen without collisions, as shown

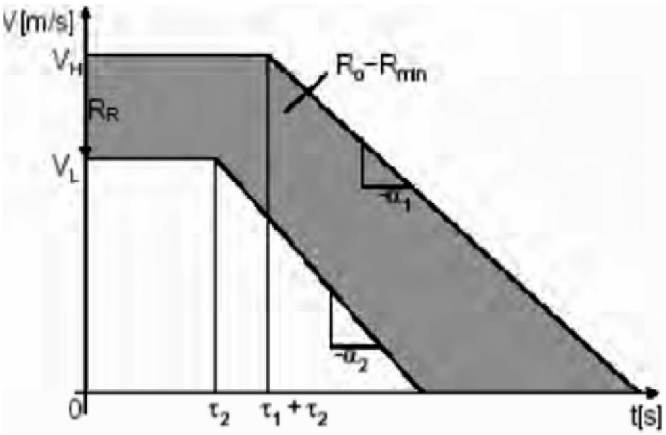

Figure 2: Worst case in Mazda algorithm[2] in equation 1

$$R_0 = 1/2(V_H^2/\alpha_1 - V_L^2/\alpha_2) + V_H t_1 + R_R.t_2 + R_{min} \text{.............. (1)}$$

Where R_R is the range rate, i.e., the relative velocity between the two vehicles ($R_R = V_L - V_H$), and R_{min} is a constant headway offset. The shaded area in Figure 2 is the required safety range buffer between the two vehicles needed to be maintained if the hypothetic scenario described above happen.

The system offers a warning when the actual vehicle-to-vehicle distance approaches the critical distance. The driver is warned and brakes are applied when the range is less than the critical distance as shown in Figure 3.

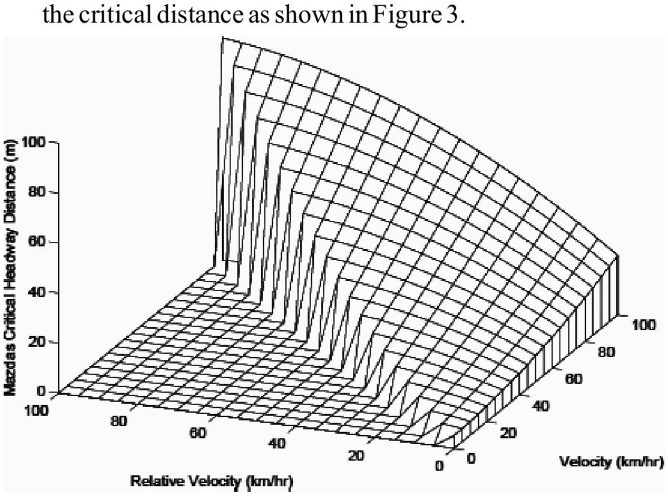

Figure 3: Mazda's Critical Braking Distance[3]

B. Honda's Algorithm

The Honda's warning algorithm is a straight line in the range rate-range plane, indicating a time to impact considerations[2]. Their braking logic has two parts selected by estimated shortest time to lead vehicle stop. The Honda algorithm considers a hypothetical scenario. It consists of two parts, dependent on whether the lead vehicle is expected to stop within the considered time range t_2. It is assumed that the lead vehicle brakes constantly at deceleration level $-\alpha_2$, while the host vehicle starts to brake after reaction time t_1 at deceleration level $-\alpha_1$. Then the safety range R_0 is estimated as the minimum range buffer needed to avoid collision until t_2 at both situations, which Automatic brake is applied to assist collision avoidance if the current range R is within R_0.

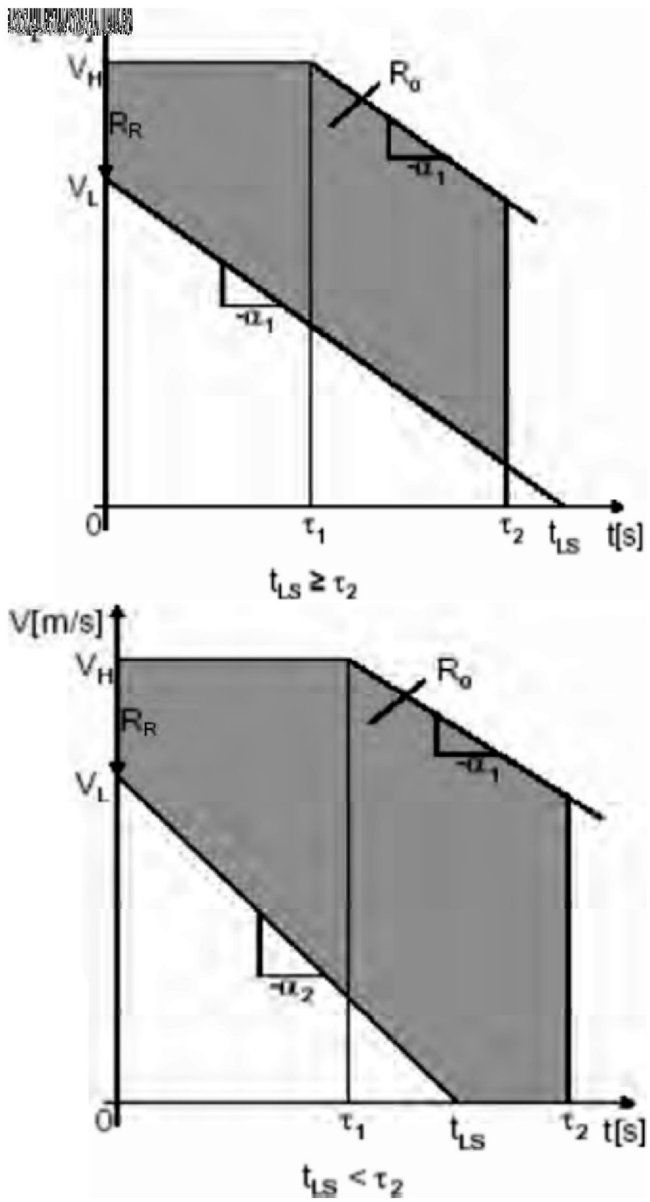

Figure 4: Interpretation of Honda Algorithm [2]

$R_0=V_H t_2 - \frac{1}{2}\alpha_2(t_2-t_1)- V_L^2/t_2;\ \ t_{LS}<t_2$, (2)

$R_0 =-R_R.t_2+ \alpha_1 t_1 t_2- 1/2\alpha_1 t;\ \ t_{LS}\geqslant t_2.$ (3)

A comparison of the critical distance plots shows that the Honda's algorithm results in a much less conservative system. Honda developed their system with the intention that it would not be conservative. It is possible for driver to begin a steering collision avoidance maneuver much later than a braking collision avoidance maneuver. Therefore, a conservative collision avoidance system might apply the brakes while the driver was attempting a steering collision avoidance maneuver. This could startle driver and possible cause them to lose control of the vehicle. Honda's system will be less likely to interfere with the normal driver habits. As a result, it may not avoid all extreme case collisions, but it should reduce the impact speed of extreme case collisions.

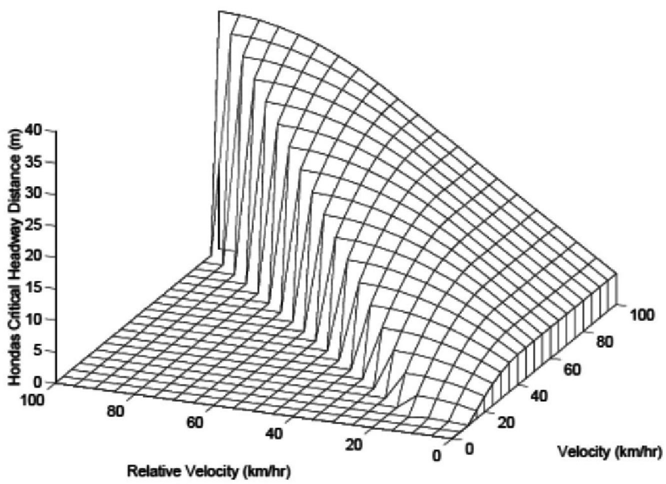

Figure 5: Honda's Braking Critical Distance[3]

C. Berkeley Algorithm

The Berkeley algorithm proposes a conservative R_w to provide a wide range of visual feedbacks to the driver, and a non-conservative R_0 to reduce undesirable effects of overriding to normal driving operations[2]. It is assumed that the lead vehicle brakes at the maximum constant deceleration of –α, while the host vehicle starts to brake after reaction time t at the same deceleration level. Note the reaction time their accounts for both driver reaction time and system delay time. The warning range R_w is estimated as the minimum range needed to avoid collisions until both the vehicles come to full stop in the above scenario, while the overriding range R_0only considers the range buffer needed from time 0 to t as:

$R_W= (V_H^2-V_L^2)/2\alpha + V_H t + R_{min}$ (4)

$R_0= -R_R.t + \frac{1}{2}\alpha t^2$ (5)

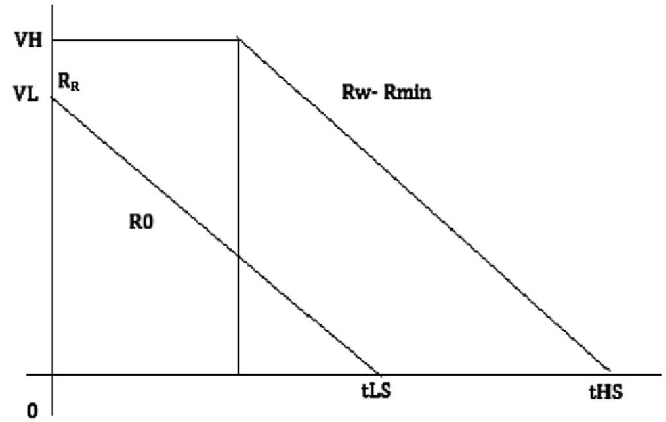

Figure 6: Interpretation of Berkeley algorithm

3. CONCLUSION AND FUTURE WORK

In this paper we have reviewed three standard algorithms for collision avoidance system. The parameters given in the report helps the driver to avoid collision and alarm when he is in crash alert timing zone. All these algorithms are verified in the past and are being carried out. But there are certain limitations too. The Mazda algorithm suits for emergency stopping of lead vehicle, thus the calculated safety distance is too large and warning time is too early which may lead to false warning. Whereas, calculated safety distances of the Honda algorithm are too small and may led to false negative. Each algorithm is suited for a particular situation and unable to adapt to other situations. In addition, these algorithms are difficult to be adapted toinclude the variation in road friction coefficients. The deceleration of lead vehicle and host vehicle cannot be accurately calculated; hence the algorithms are difficult to adapt for unknown lead vehicle parameters. As these key parameters are time varying, the warning thresholds cannot be adjusted according to actual driving conditions. In future several key parameters estimations can be developed for more accurate calculations and estimations. Parameters to find out friction coefficients are to be developed which could result for more accurate estimations. Other advanced technologies like vehicle to vehicle communication can also be included to the collision avoidance system.

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