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Collision Avoiding System (CAS)

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Abstract

CAS is a system designed to help prevent rear-end collisions with vehicles which are stationary or travelling in the same direction. Several studies have shown that driver distraction or inattentiveness is a factor in the great majority of rear end accidents. The system is aimed at alerting the driver to an imminent rear end collision both at low speeds, typical of urban driving, and at higher speeds typical of rural roads and highways.

INTRODUCTION

Since the 1960s and 1970s, the number of crashes and the fatalities and injuries associated with these crashes have dramatically decreased. This can be attributed to a series of car safety laws passed both on the national and statewide level. Historically, these improvements have tended to happen gradually. Take, for instance, the introduction of the seat belt in the 1950s. This simple device didn't make an immediate impact on drivers. In fact, for a long time, seat belt use was very low, remaining at about 10 to 15 percent nationwide. But it also the crash happened.

James K. et al.(2007), discussed the constructing of Traffic Alert and Collision Avoidance System (TCAS) has had extraordinary success in reducing the risk of mid-air collisions. Now mandated on all large transport aircraft, TCAS has been in operation for more than a decade and has prevented several catastrophic accidents. TCAS is a unique decision support system in the sense that it has been widely deployed (on more than 25,000 aircraft worldwide) and is continuously exposed to a high-tempo, complex air traffic system. TCAS is the product of carefully balancing and integrating sensor characteristics, tracker and aircraft dynamics, maneuver coordination, operational constraints, and human factors in time-critical situations. Missed or late threat detections can lead to collisions, and false alarms may cause pilots to lose trust in the system and ignore alerts, underscoring the need for a robust system design. Building on prior experience, Lincoln Laboratory recently examined potential improvements to the TCAS algorithms and monitored TCAS activity in the Boston area. Cheng-N et al. 2001, The integration of fuzzy collision-avoidance and $H\infty$ autopilot systems is proposed in this paper. Collision avoidance is one of the urgent topics on ship voyage at sea. Experts' experience is still essential when a ship is in the danger of colliding with the others nowadays although a lot of electronic voyage supported apparatuses have been equipped on ships. To include these experts' experiences to resolve the problems of collision, they designed a fuzzy collision-avoidance expert system that includes a knowledge base to store facts and rules, an inference engine to simulate experts' decision and a fuzzy interface device. Either a quartermaster or an autopilot system can then implement the avoidance action proposed in the research. To perform the ship task of collision-avoidance effectively, a robust autopilot system that is based on the state space $H\infty$ control methodology is designed to steer a ship safely for various outer surroundings at sea in performing course keeping, course-changing and route-tracking more robustly.

- Active and Passive safety

There are generally two kinds of safety systems in automobiles: passive and active. A passive safety system is anything in a car or truck that, for the most part, sits idle and operates only when necessary. A good example of this is a common seat belt. Once a passenger buckles a seat belt, the belt won't automatically lock into position until the car makes a sudden stop. Airbag systems may call passive safety, too. However, you could argue that because they rely on impact sensors that determine the severity of an accident, and use that information to determine how quickly they inflate and how long they should stay inflated, airbags could fall into the active safety category. An active safety system is very different from a passive safety system, especially when you're talking about pre-collision systems. Active systems operate based on signals and information gathered, and they typically either alert the driver to a dangerous situation or assist in important maneuvers like steering while braking. These systems actively seek out information in regards to the vehicle's current state. Although early collision detection units used various technologies like infrared waves to detect objects, most pre-collision systems today work with the help of radar. Anything that's a wave, like a sound wave, can bounce or echo. You may have experienced this by shouting down into a well or over a deep canyon, only to hear the sound of your voice bounce back and reverberate. Instead of sound, however, radar systems use radio waves. Radio waves are invisible and they can travel much farther than sound. The COLLISION AVOIDING SYSTEM consider as an active safety system that alert the driver to a dangerous situations to help him to prevent the crash accident.

-Collision avoiding Systems

Collision avoiding systems place small radar detectors up near the front of the car, usually within the grill, where they constantly send out quick bursts of high-frequency radar waves. These waves will bounce off the nearest objects and return to the sensor, where a separate unit connected to the sensor calculates how long it took for the signal to leave and bounce back. With this information, a PCS unit can determine another car's position, distance, speed and relative velocity almost immediately, and if any sudden changes in those factors could potentially cause a collision, the system can provide information or assist the driver in avoiding a potential accident. So if a COLLISION AVOIDING SYSTEM recognizes a potential car crash, it can't just sit there and let chaos ensue.

-CAS System Configuration & Components:

1-Millimeter-wave radar:
Detects vehicles within a range of about 100 meters ahead, in a 16-degree arc.

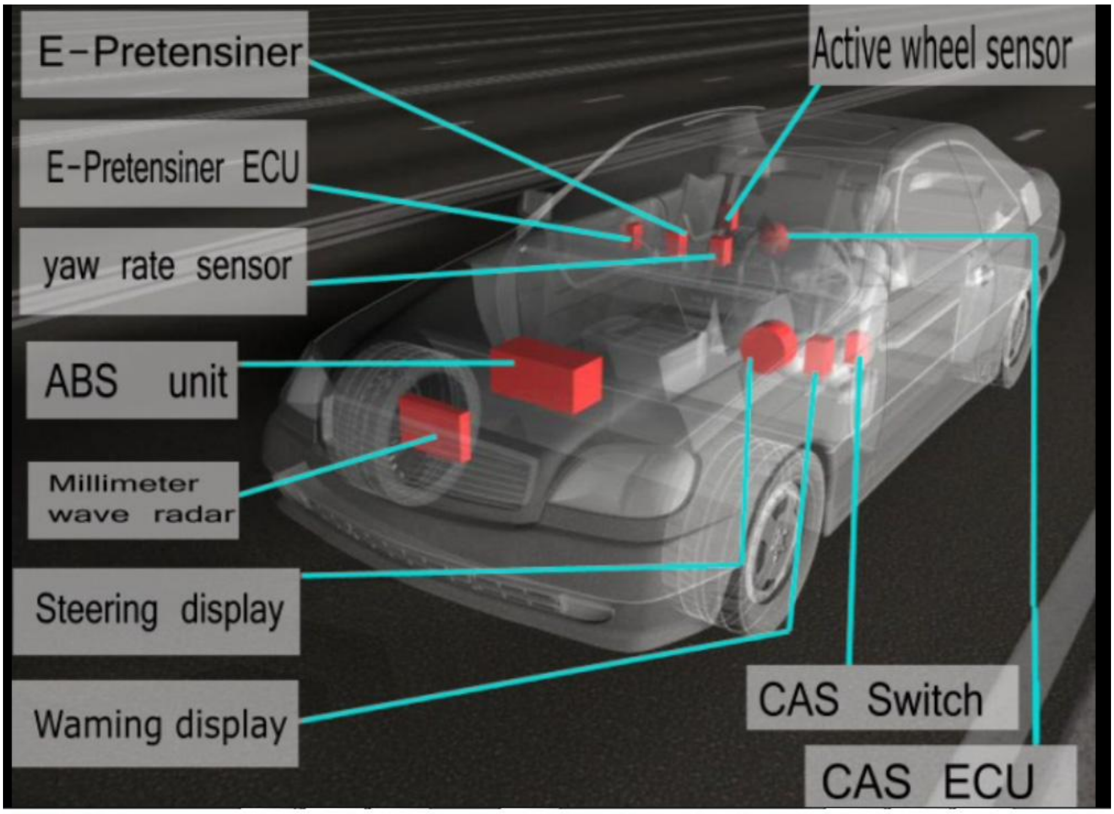
2-Sensors:
The system determines driving conditions using a range of sensors that detect factors such as yaw rate, steering angle, wheel speed, and brake pressure.

-**CAS Electronic Control Unit (ECU):**
Based on distance to the vehicle ahead and relative speed obtained from radar information, and on the anticipated vehicle path as determined based on sensor information, the ECU calculates the likelihood of a collision, and warns the driver, and in some cases activates the braking function. The ECU exchanges information as required with the E-Pretensioner, the Variable Signal Analyzer (VSA) and the Meter Unit.

1-E-Pretensioner ECU:
Sends instructions to the motorized E-Pretensioner to retract the seatbelt, based on braking instruction signals from the CMS ECU and electronically controlled brake assist signals.

2- **E-Pretensioner:**
Retracts the seatbelt using an internal motor, based on instructions from the E-Pretensioner ECU. Used in combination with conventional pretensioners.

3-Meter unit:
Receives signals from the CAS ECU, and warns the driver of potential danger using an audio alarm and a visual warning. And all these parts shown in figure 1: CAS constructions



(Figure 1: CAS construction)

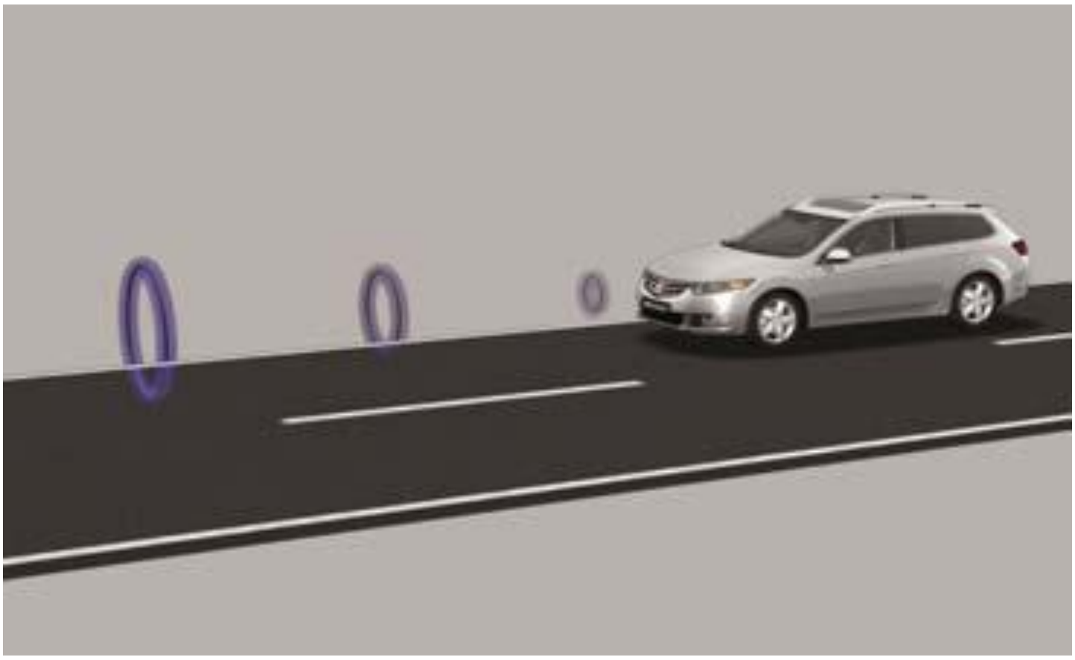
- Scope of collision avoiding system

- CAS is not switched on by default at the start of each journey. CAS can be switched on and off by the driver by means of a dashboard mounted button. CAS will remain active as long as the button is in the ‘on’ position.
- The sensor system is unable to accurately identify relative speeds less than 30km/h
- Pedestrians cannot be detected.
- Smaller motorcycles and two wheeled vehicles travelling in the edge of the road, diagonally parked vehicles and small objects such as fallen rocks may not be detected.
- The system will not function when the distance between vehicles is very short or when the conflict is very sudden such as at junctions.
- The system may not function in adverse weather conditions.

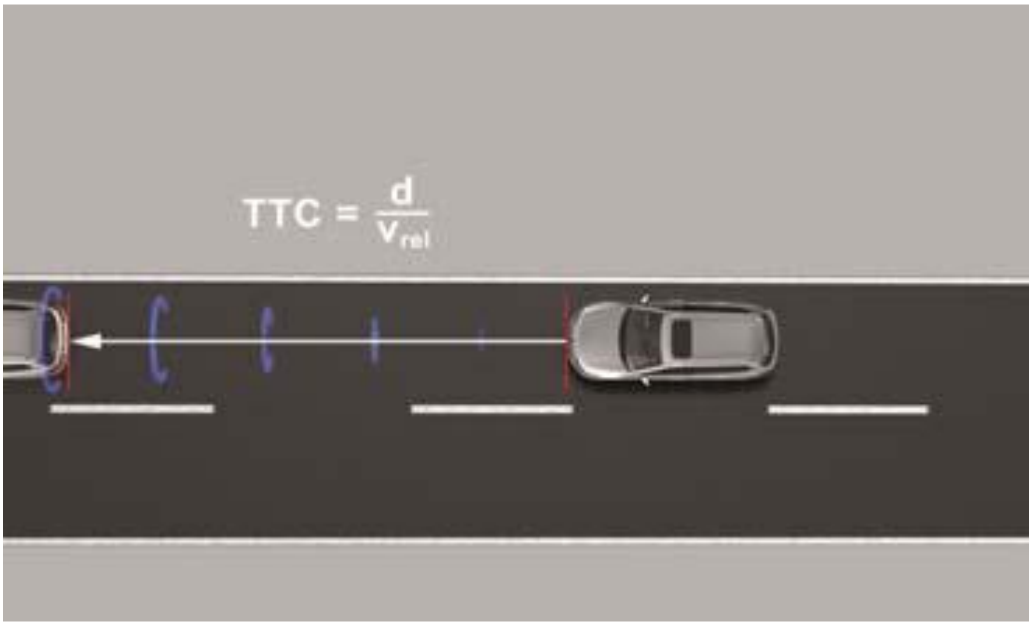
- Operation of Collision Avoiding System (CAS)

The Collision Avoiding System CAS system determines the likelihood of a collision based on driving conditions, distance to the vehicle ahead, and relative speeds, and uses visual and audio warnings to prompt the driver to take preventative action. It can also initiate braking to reduce the vehicle's speed. The CAS and E-

Pretensioner use millimeter-wave radar to detect vehicles ahead within a range of 100 meters (Figure 2), and then calculate the distance between the vehicles, the relative vehicle speeds, and the anticipated vehicle path to determine the likelihood of a collision (Figure 3).



(Figure 2: millimeter-wave radar detect vehicle)

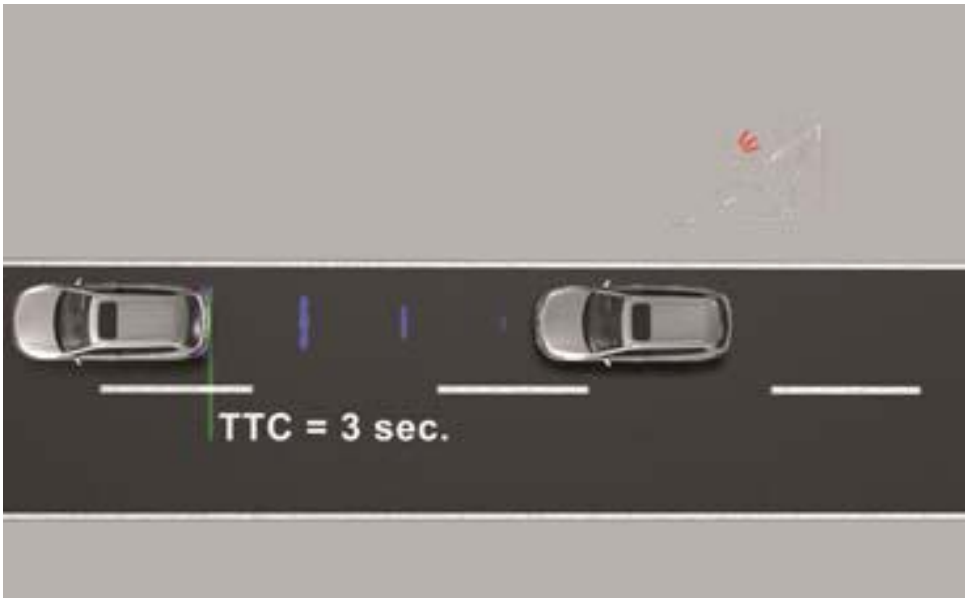


(Figure 3: calculation of likelihood of a collision)

If the system determines that a collision is likely, it sounds an alarm and provides a tactile warning: tightening the seatbelt to prompt the driver to take preventative action. The system also incorporates a number of functions to reduce impact on occupants in the event an impact is unavoidable, including a brake assist function that compensates for insufficient pedal pressure to reduce the speed of impact, and seatbelt control that increases seatbelt tension to hold the driver more securely in place. CAS is autonomous emergency braking system. At speeds above 30km/h, moving and stationary vehicles are detected along a path some 100m ahead of the vehicle. When the system senses that the car is likely to hit one of these obstacles, a three stage process is initiated.

Stage number (1):

A primary warning, comprising an audible warning and a visual 'BRAKE' warning on the dash display, is given when the space between the vehicles becomes closer than the set safety distance for 'normal avoidance' or 'normal cruising'. This warning is given at approximately three seconds time to collision as shown in Figure (4). Depending on the situation at the distance, a collision can be avoided with correct braking. At this stage brake assist will not be activated with light braking because the accident may be avoided with a normal brake application. Examples of when the collision may not be avoided at this stage include when the relative speed between vehicles is high, the grip available is low or if the driver's braking is insufficient.



(Figure 4: the distance is closer than the safety one)

Stage number (2):

If the distance between the two vehicles continues to diminish, CAS applies light braking and the driver's seatbelt pre-tensioner is activated by an electric motor which retracts the seatbelt gently two or three times, providing the driver with a tactile warning. The audible and visual warnings are also repeated. . The secondary warning is given at approximately two seconds time to collision as shown in Figure (5). At this stage the brake assist activation parameters are altered such that it is easily activated to provide maximum deceleration. Depending on the situation the collision may be avoided if the driver brakes appropriately, however in the case of high relative speed or low grip there are cases where the collision may not be avoided.

(Figure 5: second stage distance is closer)

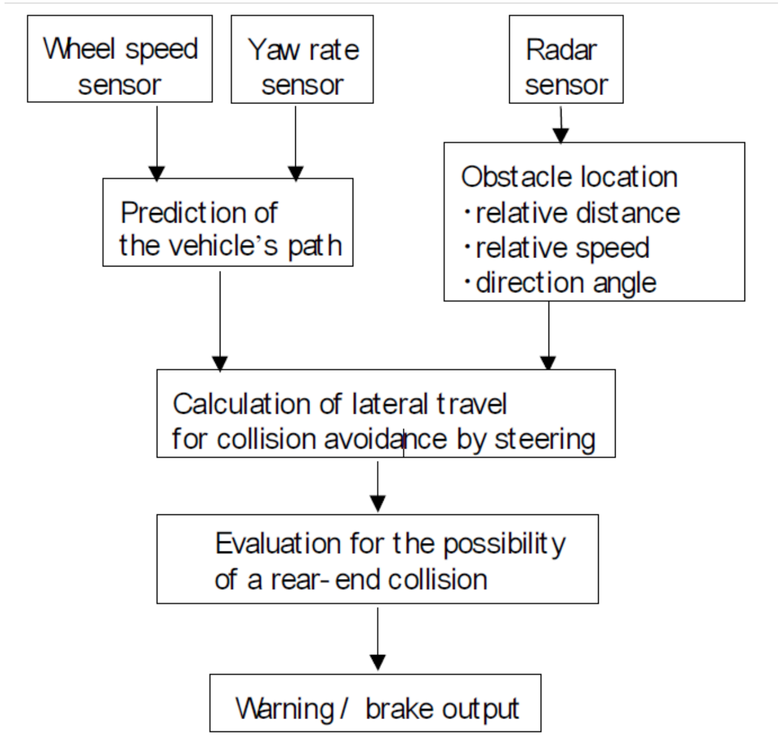
Stage number (3):

Finally, when a collision is unavoidable, And when the system judges that a collision is unavoidable, typically one seconds before impact as shown in Figure (6), the E-Pretensioner retracts the seatbelt with enough force to compensate for seatbelt slack or baggy clothing, providing even more effective driver retention than conventional seatbelt pretensioners, which only begin to operate once the collision has occurred. The CAS also activates the brakes forcefully to further reduce the speed of impact and Appling a strong brake.

(Figure 5: hard brake is applied)

Control System

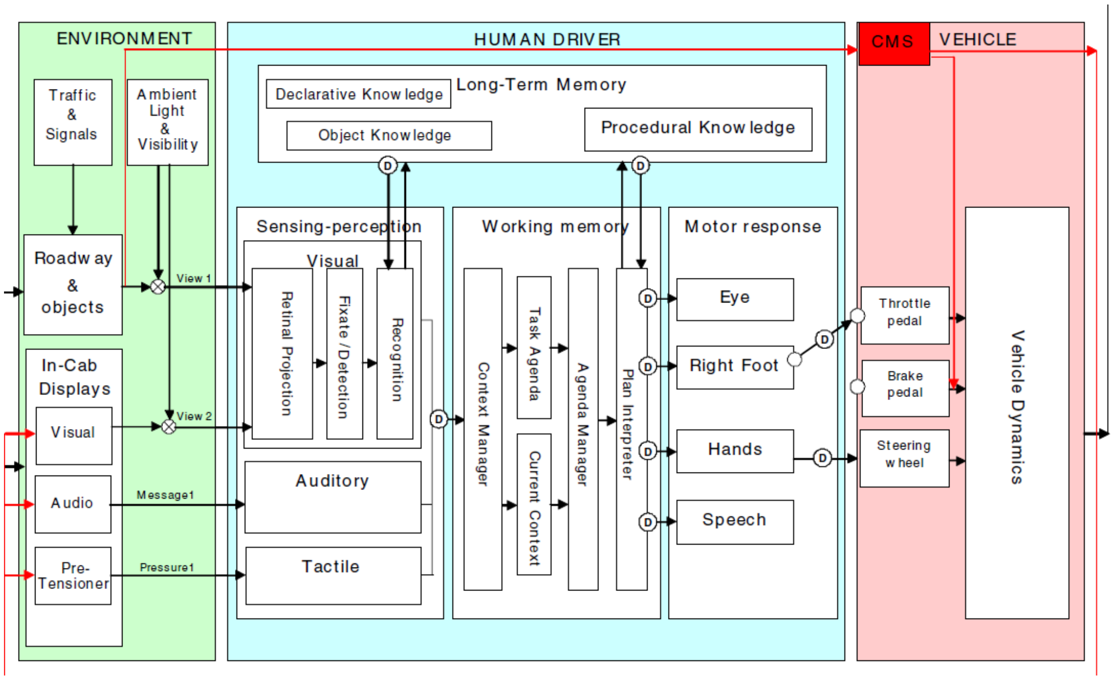
As we said before collision avoiding system is a radar-based autonomous emergency braking system. At speeds above 15km/h, moving and stationary vehicles are detected along a path some 100m ahead of the vehicle. When the system senses that the car is likely to hit one of these obstacles, a three stage process is initiated. In the first, typically around 3 seconds before impact, the driver is alerted by visual and audible warnings. In the second stage, when the system senses that a collision is still likely (typically some 2 seconds before impact), three sharp tugs are given on the seat belt and the car automatically starts to apply some braking. Finally, when a collision is unavoidable, CMBS tightens the front seat occupants' seatbelts (using reversible tensioners different from the pyrotechnic devices used during the collision itself) and applies a high level of braking force. This braking can be supplemented by the driver up to the maximum that the car is capable of. Figure (7) shows the basic control flow. The system recognizes a leading vehicle by a radar sensor, wheel speed sensor, yaw rate sensor and the subject vehicle's path is estimated from its dynamics state quantities. Then, the system calculates lateral travel, which is necessary for collision avoidance by steering, and evaluates the possibility of a rear-end crash. When the possibility of a rear-end collision becomes high, the warnings is issued, and if this state continues and avoidance becomes very difficult, emergency braking is carried out.



(Figure 7: the basic control flow for CAS)

- SIMULATION MODEL

Figure (8) shows the concept of the simulation model, which is structured similar to NASA's MIDAS program . The model has three main components: the environment, the human driver, and the vehicle.



(Figure 8: the concept of simulation model)

- **Environment Model**

The environment model contains the world outside the driver's vehicle. In this study, the environment contains the driver's intended path and the other vehicle involved in the scenario. The environment also contains the in-cab displays available to the driver; most importantly it contains the visual, audio, and pretension warnings.

- **Driver Model**

The human driver model contains four major sub modules: sensing-perception, working memory, long-term memory, and motor response. The sensing perception module processes information from the environment into sense-organ primitive form and performs basic processing of the information. The current model has three modules in sensing perception: look-ahead path prediction, speed sensing and collision detection. Currently, the collision detection module is only sensitive to CAS warnings, which cause the module to recognize that a collision is imminent. The working memory module performs higher-level processing of information. It maintains a "current context," which is a description of the current state of the world, including such things as level of traffic, weather, lighting conditions, pending events, etc. The "task agenda" is a list of tasks that the driver might want to perform. These tasks are weighted relative to the factors in the current context, creating a vector of weights for the tasks, which specifies the priority for performing each one. Tasks with low priority will not be performed due to limited capacity.

RESULTS AND DISCUSSION

Collision Detection

In the currently implemented driver model, the collision detection model is set to detect collisions only after a CAS warning occurs. As soon as the CAS warning sounds, there is a detection/recognition/decision time delay, and then a variable called “emergency flag” is set to "1" in order to indicate that the driver should initiate a collision avoidance response.

-Three stages calculation and control

As we said before there's three stages of CAS operation it will be discussed below.

- Buzzer and light warning.

When the information signal come from radar, yaw sensor and speed wheel sensor into collision avoiding system CAS ECU, the CAS ECU calculate the time by using equation (4.1) and by it programmed if the time that found is three second the CAS ECU send signal into the buzzer and the light warning to work to alert the driver that the collision will be occur in dash board as we see in figure(9) if he still in the same speed if the driver depressed the brake pedal the system stops and everything is back to normal if the time decrease below three sec the second stage will activated.

$$speed = \frac{distance}{time}\ km/hr. \quad \textbf{(1)}$$

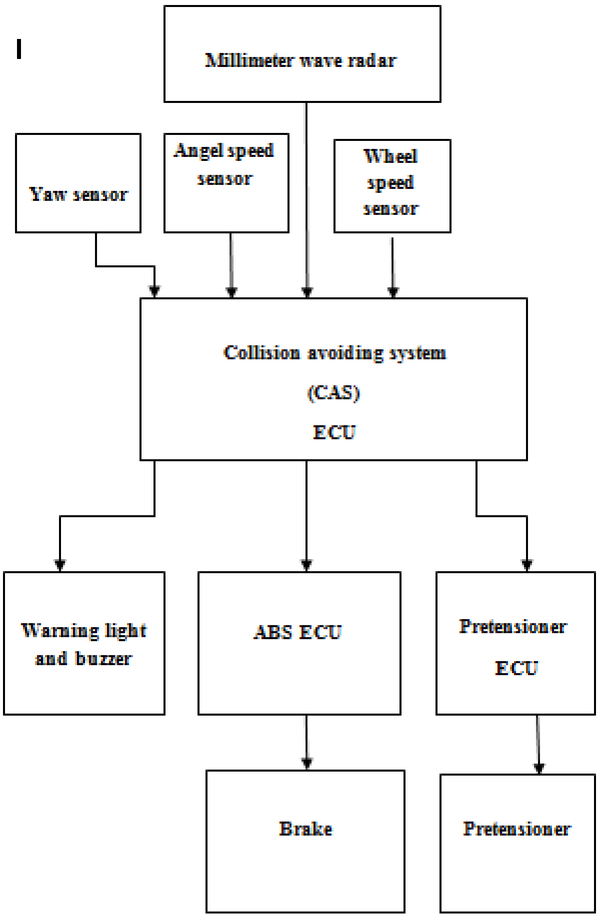
(Figure 9: indicator in the dash board)

-Light braking and tighten the seatbelt

In this step when the ECU find the time before collision is about two second the ECM order the pretensioner ECU to tighten the belt to take up any slack that may be present and order the ABS ECU to open and close the valve so it give light braking.

-Hard braking and retract seatbelt

When the information signal come from radar, yaw sensor and speed wheel sensor into integrated hydraulic unit ECU and then the integrated hydraulic unit ECU send the signal into CAS ECU, the CAS ECU calculate the time before impact if it about one second the CAS ECU order the pretnsioner ECU to retract the seat belt strongly and order the ABS ECU to fully braking as shown in figure (10).



(Figure 10: block diagram for braking stage)

- Emergency Braking

The emergency braking module contains a preprogrammed open-loop braking acceleration routine used when an emergency situation occurs.

$$emergency = G \cdot t \qquad for\ t \leq 0.2s$$
$$= C \qquad for\ t > 0.2s \quad (2).$$

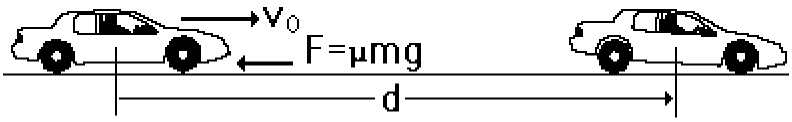
Where *emergency* is emergency braking acceleration, G is the rate of change of the braking function, and C is the maximum command acceleration level of the braking function.

- Reaction Time

It's the time of the driver in which he decide to apply the break and shift his legs from the throttle pedal to the brake pedal and it depends on his individual abilities and skill and ranges within 0.4 – 1 .s In the collision avoiding system there is no reaction time because the brake applied electronically by the system.

-Braking distance

Assuming proper operation of the brakes on the vehicle, the minimum stopping distance for a vehicle is determined by the effective coefficient of friction between the tires and the road, and the driver's reaction time in a braking situation. The friction force of the road must do enough work on the car to reduce its kinetic energy to zero. If the wheels of the car continue to turn while braking, then static friction is operating, while if the wheels are locked and sliding over the road surface, the braking force is a kinetic friction force only as shown in figure(4.5).



(Figure 4.5: static frication operate)

So the stopping distance in equation (2) is

$$d_b = \frac{v2}{2\mu g} \qquad (2)$$

Where: d_b: braking distance in (m), v: vehicle speed in (km/hr), μ: coefficient of frication, g: acceleration due to gravity (m/sec).

Table 1: sampling of calculation for distance between vehicle before and after stopping)

Speed (km/hr)	Braking distance (m)	Distance where the CAS system indicate (m)	Distance between two vehicle after braking (m)
20	1.97	5.56	3.59
30	4.42	8.34	3.92
40	7.78	11.12	3.34
50	12.3	13.9	1.6
60	17.7	16.68	Crash
70	24.11	19.46	Crash
80	31.49	22.24	Crash
90	39.86	25.02	Crash
100	49.25	27.8	Crash
120	59.54	33.36	Crash
140	70.86	38.92	Crash

We see from this sample of calculation that the CAS make the vehicle stops before crashing at speed below 60km/hr and the CAS system reduce the speed of the crashing at speed above 60km/hr

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