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A Survey on Evaluation and Calculation of Ranges of Knowledge in Inter-Vehicle Communications

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***Abstract* – This paper studies the important areas in which decisions affecting safety applications are dealt with. First, consider research done in the field the amount of PRT (Perception-Reaction Time). Then, to define the boundaries of knowledge relative position of the two vehicles based on the type of knowledge needed to prevent accidents show, we will present. In this paper, how to calculate the area of awareness for two important applications in automotive safety included of EBW (Emergency Brake Warning), FCW (Forward Collision Warning) has been described.**

***Keywords* – COAR, EBW, FCW, PRT, VAR.**

I. Introduction

Knowledge of the current state of the dynamic system, in which the environment is changing rapidly, would be crucial. Situational awareness is defined in [2004] as "the perception of environmental elements within a volume of time and space, meaning it project status in the near future" is defined. With the advances in motor vehicle caused by the expansion and road transport, vehicle safety is dependent on several variables. So create situational awareness for vehicles, in the auto industry has become a major challenge. Sensors, radars and cameras are now the most important technologies in vehicles are used to create situational awareness. Use CCWS systems due to its numerous advantages, has been widely addressed in recent decades. The objective of the system ultimately is to increase road safety. Situational awareness system is an important part of CCWS. In this section we collect the necessary data for warning purposes. Current status based on existing data in messages is important. In fact, the current assessment, based on existing data from other vehicles and estimate its future state until a new message is done. Transmitted warnings to the driver (via a warning sound, video, etc.) can control the amount of time required for the driver to reduce the response to a particular event. Reduction in PRT varies for different drivers.

II. Perception-Reaction Time (PRT)

Early notification of a driver's accident risk can occur even for half a second and more than 60% to prevent road accidents [1997]. Generally, the driver reaction time to an event such as an accident is divided into several periods. First, the driver should use the 5 senses, especially vision and understand the event processing. Time perception factors such as driver age, environmental conditions (weather, winding roads, etc.) and is also dependent on the driver's mental state. Taking all of these cases can be very effective in determining the reaction time of a driver. But in reality this is not possible because these values are highly variable. There is not the possibility of considering the exact amount, but it can be considered an average. Second, the driver pressing the brake pedal reacts to the perception.

Much research has been done on determining PRT. In [1989], different intervals for different roads proposed that the 1.5 seconds starting for the road with a low density and 0.3 second terminating for Highway out of Town. Table 1 shows the research model and estimates.

Table 1: Hooper and McGee. Chain Model for PRT

Components		Time (s)
Perception	Delay	0.31
	Eye Movement	0.09
	Fixation	0.2
	Recognition	0.5
Reaction	Braking	1.24

All statistical studies of the distribution function of PRT have shown that it does not follow from Normal or Gaussian distribution, the distribution of log - normal used. In [1995], there is a probability distribution function.

$$f(t) = \frac{1}{\sqrt{2\pi}\xi t}\exp\left[\left(\frac{LN(t)-\gamma}{\xi}\right)^2\right] \quad (1)$$

The two parameters that determine the overall shape of the distribution are μ, ξ. These two parameters are related to the mean values and standard deviation of PRT statistical data.

$$\xi^2 = LN\left(1-\frac{\sigma^2}{\mu^2}\right) \quad (2)$$

$$\gamma = LN\left(\frac{\mu}{\sqrt{1+\frac{\sigma^2}{\mu^2}}}\right) \quad (3)$$

That μ and δ are sequentially average and standard deviations of statistical samples.

For the study[2000][2009], a period when the driver of a car accident, according to the type of warning (brake lights, alarm system) can comprehend, Between 0.5 to 1.25 sec calculated and Incident response time and understanding for both 0.2 seconds is considered. Although these values are differences in the various studies in the field of human factors and warning type will affect severity of the incident but studies on inter-vehicle networks have been considered for simplicity in calculating the average case.

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III. Range of Knowledge (Visual Awareness, Communication Awareness)

We determined the risk and also the situational awareness needed to escape from it, the limits of knowledge have been defined. In this paper, two types of resource for the driver's situational awareness requirements have been considered include Visual awareness, Communication awareness.

Based on this definition (VAR & COAR) have been considered in its definition is as follows:

A. Visual awareness (VAR)

Distance that the driver in the event of an accident, it's apparent legitimate, respond to it in good time to prevent the accident. The time of for the research, has done in [2009], between 0.7 - 1.25 seconds. Climatic conditions can affect a driver's perception and then of course it can vary on his reaction. Situate that due to weather conditions or road conditions (screws and voltage) to be created VAR virtually nonexistent. VAR refers to interval that if there is good visibility, the driver can control the vehicle. Human factors and environmental factors on the VAR, Is beyond the scope of this work.

B. Communication Awareness (COAR)

All Emphasis on the distance that if drivers be aware of the warning by Inter-vehicle communications, can control vehicle and auto accident can be prevented. Based on research conducted PRT over warning between 0.5 and 0.7 is measured. If the level of awareness is at a high level and timely warning can reach them at close distance to each other can be placed. In figure1 Scope of knowledge for two cars is shown.

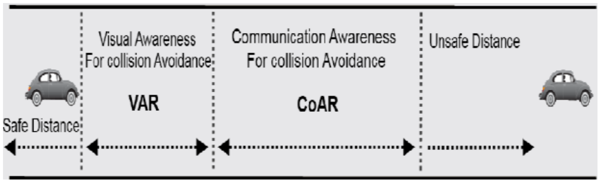

Fig.1. Scope of Knowledge and Safety

According to Figure 1, if the vehicle is located some distance away in case of each event will be secure. This is also true for non-safety if placed at a distance closer than the distance of the rear vehicle safety, any event to the rear car can be dangerous. According to the safety board's definition will vary depending on the application and the event occurred. Our calculations due to the simplicity of the ideas about the two events have gained an accident or sudden braking. In this paper, the applications of Emergency Brake Warning (EBW), Forward Collision Warning (FBW) are selected. The reason for these two applications is been the same equations of motion and ease of use of the vehicles in the calculation of the limits of knowledge.

C. Scope of knowledge for two cars

Distance In the event of an accident, the vehicle is randomly stopped at a point x and the rear vehicle at a distance d from the event, after getting an accident alert, which can be used as brake lights or warning alarm of car accident, is braked, and constant acceleration d_H after distance of x_{stop} will stop. Constant acceleration d_H is the maximum acceleration reduction that car can be brake. If x_{stop} is bigger than two cars will crash together. In this process the rear vehicle speed and acceleration would be helpful in determining x_{stop}. The distance in the PRT period should also be considered in case of acceleration, the rear vehicle speed will increase after PRT the size of $a * t_{PR}$. Accordingly, VAR and COAR for occurrence of accidents are calculated from following equations.

$$VAR = x_{PR} + \frac{\left(v_H + a * t_{r_{Visual}}\right)^2}{2d_H} \quad (4)$$

$$COAR = x_{PR} + \frac{\left(v_H + a * t_{r_{Warning}}\right)^2}{2d_H} \quad (5)$$

That $t_{r_{Visual}}$ and $t_{r_{Warning}}$ are respectively visual alarm mode and alarm systems. Distance x_{PR} shows the distance traveled in PRT. Kind of PRT is very important. This board gives us minimum distance in best conditions. Limits of knowledge for Emergency Brake Warning application are different. In emergency braking the car has strong brakes, the exact location of the brake will not stop, but the distance is equal to x_{stop} this will happen. This distance makes it possible for the rear car until have been greater distances for x_{stop}. The vehicles can be placed closer than braking vehicle. So that the limits of knowledge based on relations 3 and 4 for emergency braking warning application will be obtained. To distinguish between areas of knowledge we use two VARB and COARB applications.

$$VARB = x_{PR} + \frac{\left(v_H + a * t_{r_{Visual}}\right)^2}{2d_H} - x_{stop} \quad (6)$$

$$COARB = x_{PR} + \frac{\left(v_H + a * t_{r_{Warning}}\right)^2}{2d_H} - x_{stop} \quad (7)$$

Important point in calculating the area of awareness for emergency braking mode is determination of x_{stop}. Therefore, the position of the vehicle relative to the event occurred, x_{stop} can be strong braking distance mode.

D. Limits of Knowledge in the chain of cars

In the chain of cars reaction shows per vehicle compared to the vehicle ahead. Stop and Overall vehicle ahead is dependent on another car. For this purpose, we need to determine the stopping point for each vehicle with x is shown. This point shows the distance reached by the front car and the current distance is added to the rear car, for risk assessment is required. In calculating this distance, will be effective the probability of receiving or not receiving messages. For this purpose we consider two general conditions for determining where to stop vehicle I

1-It hurtles with vehicle i-1.

2- Still there is time to avoid the accident with vehicle i-1.

First stop is the point of the crash, which can easily be obtained. This condition occurs when the distance between the two vehicles is very close and the rear vehicle is located in insecure areas.

Second the stop location depends on receiving messages. The second case occurs when there is still time for rear car to get in to COAR. Therefore, to obtain a stopping place, Diagnosis of receiving the message is very important. Therefore, the following equation will be used to determine a stopping place.

$$x_{stop} = x_{tr} + \sum_{i=1}^{n}(1-P)^{i} * x_m \quad (8)$$

x_{tr} is distance traveled in PRT ,that it is calculated from equation of motion in bellow.

$$x_{tr} = \frac{1}{2}at_r^2 + vt_r \quad (9)$$

The following equation shows how to calculate x_m(distance traveled If a message is not reaching)

$$x_m = \frac{1}{2}a\left(\frac{1}{\lambda}\right)^2 + v\left(\frac{1}{\lambda}\right) \quad (10)$$

With having a value of x_{stop} calculation the area of knowledge would be possible.

IV. Conclusion

In this paper we discuss the importance of situational awareness and expression that we create awareness on Perception-Reaction Time is effective. The work done in the field of PRT was noted. Then, using the difference the warnings and cautions could make in time defined the limits of our knowledge. We defined scope of knowledge for VAR and COAR. Also noted that the range of knowledge and how it is calculated depends on the type of application. Finally two major application areas of awareness for collision warning and emergency brake warning were calculated.

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