The Collision Avoidance System Using the Doppler Effect between Vehicles in the intersection

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1. Introduction

Recently, although the road traffic plays an important role in today's social system, a present automobile traffic has various problems such as traffic accident and traffic jam. Therefore Intelligent Transport System (ITS) is researched actively to aim at the effective service and the security of the vehicle, but the present conditions of traffic accidents are still serious, so it is necessary not only to investigate the accident after happening, but also to avoid traffic accident. In this paper, we construct systems preventing a traffic accident between the vehicles by the wireless communication.

2. The proposed method

We discuss a system which can detect a car existing in the blind spot only by observation car without using the infrastructure such as roadside units using radio waves. At that time, it installs " Radio Wave Mirror" in the crossing center in order not to depend on the environment around the crossing. Through Radio Wave Mirror we identify the reflection wave that seems to communicate with a car existing in the blind spot.

We estimate the speed of a target car existing in the blind spot using the Doppler Effect based on the path which is identified.

$$\Delta v = \frac{\Delta l}{\Delta t} \cdots(1) \quad \Delta f_D = \frac{\Delta v}{\lambda} \cdots(2)$$

Δf_D : Doppler frequency (Hz) λ : Wavelength(m)

Δl : Path length(m) Δt : Time(s)

The speed of the target car is estimated from the Doppler frequency which is demanded.

$$\Delta f_D = \frac{v_1 \cos\theta_1 + v_2 \cos\theta_2}{\lambda} \cdots(3)$$

$$v_2 = \frac{\Delta f_D \cdot \lambda - v_1 \cos\theta_1}{\cos\theta_2} \cdots(4)$$

v_1 : Speed of the observation car(m/s)

v_2 : Speed of the target car(m/s)

θ_1 : Output angle degree from the target car (°)

θ_2 : Arrival angle to the observation car (°)

The speed of the observation car is known and supposes that it can acquire the position of it from GPS. It can count the position of the target car backward from it of the observation car and the arrival time for path. In addition, the path to discuss uses the property that is the reflection wave. Then we can lead the arrival angle to the observation car and demand the speed of the target car.

3. System models and Simulation

We analyze the radio wave propagation situation in the assumption accident scene at the crossing by the simulation software (Raplab) with ray tracing. In that case, we assume to use that the transmitting antenna is standard dipole antenna and the receiving antenna is array antennas. [1] The speed of each cars is assumed to be constant.

This paper assumes intersection environment described in Fig 1, Radio Wave Mirror Model described in Fig 2, and Intersection of Raplab Model described in

Fig3. Table 1 and Table 2 contain a summary of the simulation parameter setting. Fig 4 shows Image of ray tracing in this simulation and the target path. The path to discuss is involved in only the target car existing in the blind spot, the observation car, and Radio Wave mirror. From the path, the speed of the target car is estimated using (2) and (4).Fig 5 shows the graph which compared the theoretical value which the estimated result.

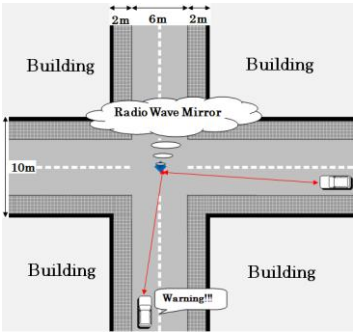

Fig 1.Intersection Model

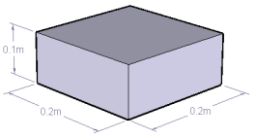

Fig 2.Radio Wave Mirror Model

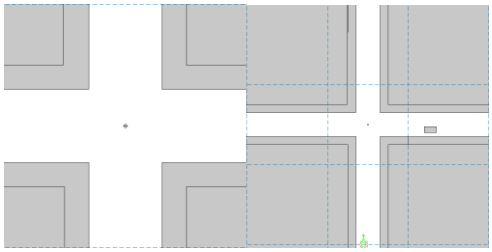

Fig3.Intersection of Raplab Model

Table 1.System Parameter

Transmission Power(W)	0.01
Carrier Frequency(MHz)	700
Height of Transmission and Reception(m)	0.2
Speed of the observation car(m/s)	10
Speed of the target car(m/s)	12.5

Table 2.Materials Parameter

Materials	Dielectric Constant [F/m]	Conductivity[S/m]
metal	8.85×10^{-12}	$5.76 \times 10^{+6}$
concrete	5.99×10^{-11}	2.30×10^{-3}

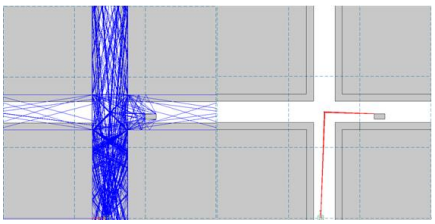

Fig 4.Image of Ray tracing in This Simulation And The Target Path

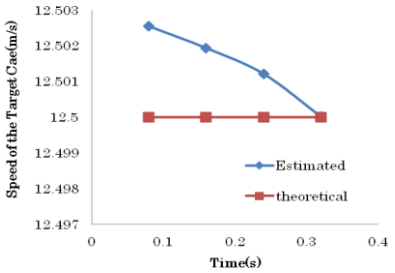

Fig 5. Estimated and Theoretical value

4. Conclusion

From this discussion, if we were able to acquire observation car positional information with GPS and an arrival angle in the crossing model which installed Radio Wave Mirror, the speed of the target car is estimated correctly by using the Doppler effect of radio wave. That is, it is possible to detect a target car existing in the blind spot only by one observation car without depending on the environment around the crossing. Also, Future problems include the further effectiveness of the suggestion method by the estimate of the arrival angle, evaluations in more detailed propagation environment.

5. References

[1] Nobuyoshi Kikuma, "ADAPTIVE SIGNAL PROCESSING with Array Antenna" in Japanese, 1999 by Science and Technology Publishing Company, Inc.